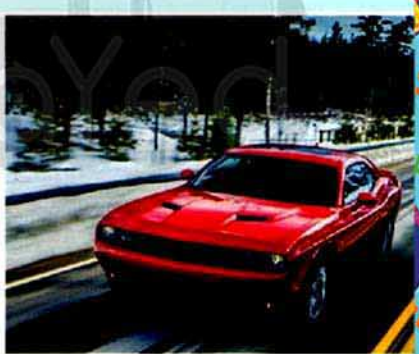
CONTENTS

- Important physical and mathematical basics.
- Table of physical quantities, their symbols, units of measurement and dimensional formulae.

To access to the unstudied part of the previous year (from 15 March to the end of the syllabus) scan this QR code.

UNIT ONE Physical Quantities and Measuring Units.

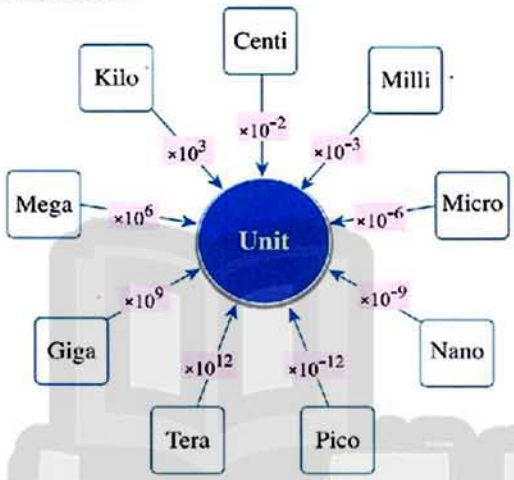
UNIT TWO Linear Motion.



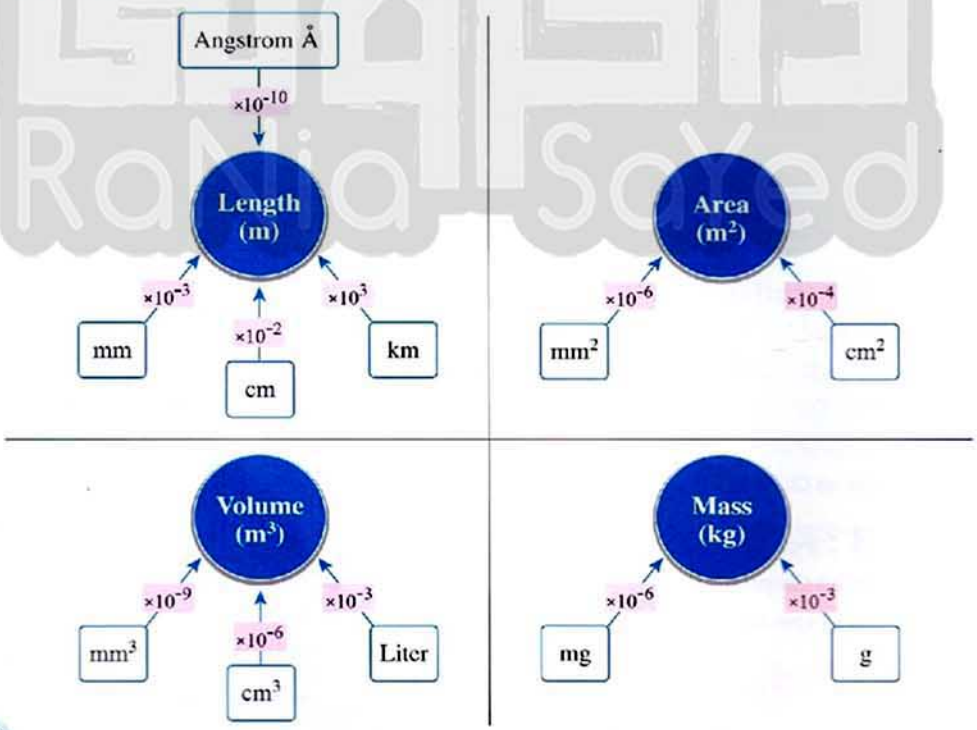
10 Model Exams.

Important physical and mathematical basics :

1 Some units conversion :

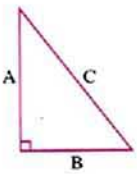


2 Conversions of some specific units :



3 Pythagoras theorem :

In the right triangle the square of the hypotenuse is equal to the sum of squares of the other two sides



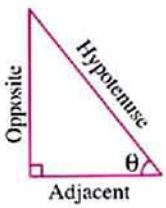
i.e. $C^2 = A^2 + B^2$

$\therefore C = \sqrt{A^2 + B^2}$

Where : C is the hypotenuse and A, B are the other two sides.

4 Trigonometrical relations :

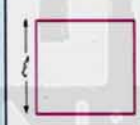
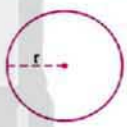
In the right triangle



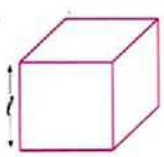
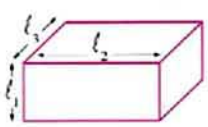
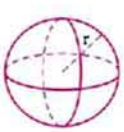
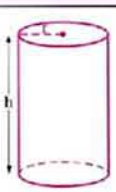
$$\sin\theta = \frac{\text{Opposite}}{\text{Hypotenuse}} \quad , \quad \cos\theta = \frac{\text{Adjacent}}{\text{Hypotenuse}} \quad , \quad \tan\theta = \frac{\text{Opposite}}{\text{Adjacent}}$$

5 Perimeters, areas and volumes of some geometrical figures :

A. Plane geometrical figures :

Geometrical figure	Square	Rectangle	Triangle	Circle
Figure shape				
Perimeter	4ℓ	$2(\ell_1 + \ell_2)$	$\ell_1 + \ell_2 + \ell_3$	$2\pi r$
Area	ℓ^2	$\ell_1 \times \ell_2$	$\frac{1}{2}\ell_1 \times h$	πr^2

B. Solid geometrical figures :

Geometrical figure	Cube	Cuboid	Sphere	Cylinder
Figure shape				
Volume	ℓ^3	$\ell_1 \times \ell_2 \times \ell_3$	$\frac{4}{3}\pi r^3$	$\pi r^2 \times h$

6 Graphical relations between two variables :

⊙ The graphical relation between two quantities on the x and y axes may be as the following :

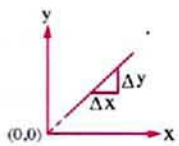
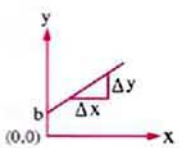
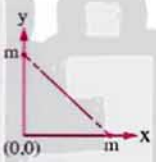
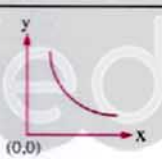
Relation	Graph
$y = m x + b$ • At : $b = 0$ - The relation is a straight line passing by the origin (0 , 0). - Slope = $m = \frac{\Delta y}{\Delta x}$	
• At : $b \neq 0$ - The relation is a straight line intersecting y-axis at point (0 , b). - Slope = $m = \frac{\Delta y}{\Delta x}$	
$y = m - x$ • Sum of the two quantities at any point = constant - At : $x = 0$, y = constant = m - At : $y = 0$, x = constant = m - Slope is negative value.	
$y = \frac{m}{x}$ • Product of the two quantities at any point = constant	

Table of physical quantities, their symbols, units of measurement and dimensional formulae

Physical quantity	Symbol	Unit of measurement		Dimensional formula
Length	ℓ	meter	m	L
Distance	s	meter	m	L
Displacement	d	meter	m	L
Radius	r	meter	m	L
Mass	m	kilogram	kg	M
Time	t	second	s	T
Area	A	meter^2	m^2	L^2
Volume	V	meter^3	m^3	L^3
Electric current intensity	I	ampere	A	-
Absolute temperature	T	kelvin	K	-
Amount of material	n	mole	mol	-
Luminous intensity	I_v	candela	cd	-
Angle measure	-	radian	radian	-

Physical quantity	Symbol	Unit of measurement		Dimensional formula
Solid angle measure	-	steradian	steradian	-
Density	ρ	kilogram/meter^3	kg/m^3	ML^{-3}
Velocity Instantaneous velocity	v	meter/second	m/s	LT^{-1}
Average velocity	$\bar{v}$	meter/second	m/s	LT^{-1}
Acceleration	a	meter/second^2	m/s^2	LT^{-2}
Acceleration due to gravity	g	meter/second^2	m/s^2	LT^{-2}
Force	F	kg.meter/s^2 Or newton	kg.m/s^2 N	MLT^{-2}

UNIT 1

Physical Quantities and Measuring Units

Unit objectives

By the end of this unit, the student will be able to :

Chapter 1 :

- Identify the fundamental and derived physical quantities.
- Derive the dimensional formula of physical quantities.
- State the fundamental physical quantities in the International system and their units.
- Name the tools used to measure length, mass and time.
- Derive the international units of some derived physical quantities.
- Apply the dimensional formula to verify the physical relations.
- Identify how to find the error in measurement.
- Identify the reasons to have an error in measurement.

Chapter 2 :

- Compare between the scalar and vector physical quantities.
- Perform scalar (dot) product for vector quantities.
- Perform vector (cross) product for vector quantities.

Chapter 1

Physical Measurements.

Lesson 1 : Physical Measurements.

Lesson 2 : Types of Measurement & Measurement Error.

► **Model Exam on Chapter 1.**

Chapter 2

Scalar and Vector Quantities.

► **Model Exam on Chapter 2.**

► **Accumulative Exam on Unit 1.**

Chapter 1

LESSON ONE

Physical Measurements

⊙ Measurements translate our daily observations into quantitative amounts that can be expressed in terms of numerals, **for example**; in the beam balance the measurement of an unknown mass in one pan which is balanced against the known masses in the other pan is actually just a process of comparing the unknown mass with the known masses. Thus, the **measurement process** is the process of comparing an unknown quantity with another known quantity of its kind (called the unit of measurement) to find out how many times the first includes the second.

Key Elements of Measurement Process

- First: **Physical quantities**
- Second: **Measuring tools**
- Third: **Measuring units**

First Physical quantities

⊙ The quantities which we are dealing with in our daily life such as mass, length, time ... etc. are called **physical quantities** and can be classified into :

❶ Fundamental physical quantities

They are physical quantities that cannot be defined in terms of other physical quantities.

Examples

• Length. • Time. • Mass.

Application

The length of a boy = ℓ

The length of the boy is considered a fundamental quantity because no other physical quantity is needed to define length.
i.e. Length is defined by itself.

❷ Derived physical quantities

They are physical quantities that can be defined in terms of the fundamental physical quantities.

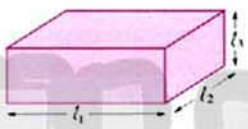
Examples

• Volume. • Speed. • Acceleration.

Application

Volume of a cuboid = Length × Width × Height

$V = \ell_1 \times \ell_2 \times \ell_3$



The volume of the cuboid is considered a derived quantity because the volume is defined in terms of the lengths of the cuboid dimensions,
i.e. Volume is derived from length.

Integration of Physics with Mathematics :

⊙ The relation among physical quantities can be expressed by **mathematical equations**.

For Example :

When a moving body covers a displacement (d) in time (t), its velocity (v) can be expressed as :

$\text{Velocity} = \frac{\text{Displacement}}{\text{Time}}$ Or $v = \frac{d}{t}$ this relation is called a **physical mathematical equation** which is a shorthand formula to give a physical illustration of a particular indication.

Second Measuring tools

In ancient times

Man was using :
- parts of his body as tools of measurement such as the arm, the hand span and the foot as tools to measure length.
- natural phenomena as tools of measurement such as the sunrise, the sunset and the Moon phases to measure time.

UNIT 1

Recently The measuring tools have been tremendously developed in the context of the great industrial evolution next to the Second World War. Consequently, these tools were very helpful to man in describing phenomena accurately and exploring facts.

- The used measuring tool depends on the physical quantity to be measured, so the first step to measure any physical quantity is to choose the suitable measuring tool.

The next section shows some ancient and modern tools used for measuring (length, mass and time) :

1 Length	2 Mass	3 Time
Ruler 	Roman scale 	Hourglass 
Meter tape 	Beam balance 	Clock 
Vernier caliper 	Analog scale 	Stopwatch 
Micrometer 	Digital balance 	Digital watch 

Test yourself

Choose : The suitable tool for measuring the radius of a small metallic sphere is .....

(a) the ruler (b) the vernier caliper

(c) the meter tape (d) the sensitive balance

.....

Practical Experiment

Measuring length using the vernier caliper.

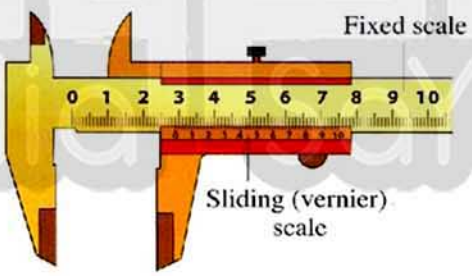
1. Experiment Objective :

- Measuring short lengths precisely.

2. Main parts :

Calipers have two jaws; each is attached to a scale :

- A fixed scale (one division = 1 mm).
- A sliding (vernier) scale : can slide along the fixed scale and graduated into a number of divisions (one division = 0.9 mm).



3. Procedure :

1. The object is placed between the two jaws of the caliper and gently pressed.
2. The length of the object is determined from the relation :

   The length = X + x

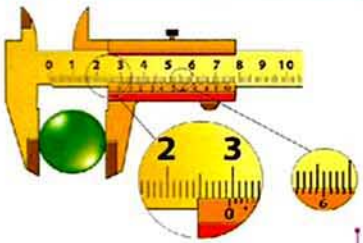
   where : (X) is the reading on the fixed scale which is recorded before the zero mark of the vernier scale.

   (x) is the vernier reading which is determined by finding out the mark on the vernier scale that perfectly lines up with one of the marks on the fixed scale and multiplying it by the difference between the divisions on the fixed scale and the divisions on the vernier scale (0.1 mm).

UNIT 1

Example

Using the opposite figure calculate the external diameter of the ball.



Solution

The fixed scale reading (X) = 29 mm

The vernier scale reading (x) :

$x = 6 \times 0.1 = 0.6$ mm

∴ The external diameter of the ball = X + x = 29 + 0.6 = 29.6 mm

Third Measuring units

⊙ Each physical quantity, either fundamental or derived, has a measuring unit because a quantity without its unit is meaningless, **for example :**

The mass of a body = 5

(The absence of a measuring unit makes us puzzled because we can't estimate the mass).

The mass of a body = 5 kg

(The quantity is fully clarified when there is a unit of measurement).

*** There is a number of systems to specify the measuring units of the fundamental physical quantities such as :**

1. The French system. 2. The British system. 3. The Metric system.

⊃ The following table shows the measuring units in each of the French, the British and the Metric systems :

The fundamental physical quantity \ System of units	Units of measurement		
	The French system (Gaussian system) (C.G.S)	The British system (F.P.S)	The Metric system (M.K.S)
Length (ℓ)	Centimeter (cm)	Foot (ft)	Meter (m)
Mass (m)	Gram (g)	Pound (ℓb)	Kilogram (kg)
Time (t)	Second (s)	Second (s)	Second (s)

International system of units (SI units) :

* In September 23, 1999 NASA did a mistake when the communication with the mars climate orbiter (spacecraft) was lost which was built at a cost of 125 million dollars. This happened due to the failure of the ground based computer of NASA to use the International system of units in sending the instructions to the orbiter.
* The International system of units (The Modern Metric System) dates back to year 1875 and was based on the Metric system.
* In the General Conference of Weights and Measures in 1960, scientists agreed to add other four fundamental physical quantities to the Metric system to have an International system of units which is used in all scientific fields all over the world.

➲ The following table gives the measuring units in the International system :

	The physical quantity	The international unit
1	Length (ℓ)	Meter (m)
2	Mass (m)	Kilogram (kg)
3	Time (t)	Second (s)
4	Electric current intensity (I)	Ampere (A)
5	The absolute temperature (T)	Kelvin (K)
6	Amount of material (n)	Mole (mol)
7	Luminous intensity (I_v)	Candela (cd)

Then, two other units are added which are :

8	Angle measure	Radian
9	Solid angle measure	Steradian

* All other SI units can be derived from these fundamental (base) units, **for example :** The measuring unit of volume is (m^3) which is a derived unit from the measuring unit of length (m).
* All units of other systems can be converted into the International system, **for example :**
  - To convert from the French system to the International system :
    1 g = 0.001 kg , 1 cm = 0.01 m

UNIT 1

Multiples and fractions of units in the International system

- A physical quantity is usually described by a numeral and a unit of measurement, but in some cases these values are :
  - **Very huge :** for example the distance between two stars is very vast and may be in the range of (100 000 000 000 000 000 m).
  - **Very minute :** for example the spacing distance between atoms in solids is estimated by nearly (0.000 000 001 m).
- It is very difficult to read such values. We prefer to express these values in the form of power of 10, so :
  - The distance between two stars can be written as (1×10^{17} m).
  - The spacing distance between atoms in solids can be written as (1×10^{-9} m).

Quantity	Standard formula
1 0 0 0 0 0 (+5)	10^5
(-5) 0. 0 0 0 0 1	10^{-5}

Remember

$10^5 \times 10^{-4} = 10^{5+(-4)} = 10$

$\frac{10^5}{10^{-4}} = 10^{5-(-4)} = 10^9$

This way of expressing the magnitude of physical quantities is known as "**the standard formula**".

The factors $10^{\pm x}$ are given specific prefixes. This is shown in the following table :

Factor	10^{-9}	10^{-6}	10^{-3}	10^{-2}	10^{2}	10^{3}	10^{6}	10^{9}
Prefix	nano	micro	milli	centi	hecto	kilo	Mega	Giga
Symbol	n	μ	m	c	h	k	M	G

- It's easy in the International system to calculate the multiples and fractions of all the measuring units in the form of power of 10 than the other systems of units.

For example

$1\ km = 10^3\ m$ | $1\ mi = 1760\ yard$

Then

$23\ km = 23 \times 10^3\ m$ | $23\ mi = 23 \times 1760 = 40480\ yard$

Notes :

1. Liter = $10^{-3}\ m^3 = 10^3\ cm^3$
2. Angstrom = $10^{-10}\ m$
3. Ton = $10^3\ kg$

Example 1

A car moves a distance of 5 km , express the distance moved by the car in mm.

Solution

$5\ km = 5 \times 10^{3}\ m$

$= 5 \times 10^{3} \times 10^{3}\ mm$

$= 5 \times 10^{6}\ mm$

Example 2

The radius of a thin wire was measured by a micrometer, it was found to be 3 μm. Express the radius of the wire in km.

Solution

$3\ \mu m = 3 \times 10^{-6}\ m$

$= 3 \times 10^{-6} \times 10^{-3}\ km$

$= 3 \times 10^{-9}\ km$

Example 3

An electric current of intensity 7 milliampere (7 mA). Express this intensity in microampere (μA).

Solution

$7\ mA = 7 \times 10^{-3}\ A$

$= 7 \times 10^{-3} \times 10^{6}\ \mu A$

$= 7 \times 10^{3}\ \mu A$

2 Test yourself

If you know that the age of the universe is estimated to be approximately 14 billion years old, **so what** is the age of the universe in seconds ?
(knowing that : the solar year = 365.25 days)

.....

.....

UNIT 1

Distinguished Scientists

William Thomson :

A British scientist, who determined accurately the value of the absolute zero (the zero point on Kelvin scale). He found it to be ($-273^{\circ}C$). So, he is considered one of those who developed the Metric system.

Ahmed Zeweil :

An Egyptian scientist, who used a laser camera to study the mechanism of chemical reactions between molecules that take place in a very short time, estimated by femto-seconds ($fs = 10^{-15}s$). He won Nobel Prize in 1999.

Standard Units

- The scientists sought to find the most accurate definition for each fundamental measuring unit by preparing an ideal model for the measuring unit that is characterized by the maximum level of accuracy and stability against the time and the environmental changes. These models are called the standard units.
- **Examples of these standard units are :**

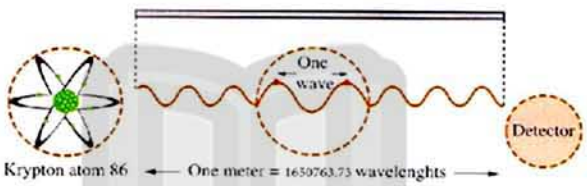
1 The standard length (The standard meter)

- French people were the first who used the meter as a standard unit for measuring the length.
- **The standard meter** is the distance between two engraved marks at the ends of a rod made of platinum and iridium alloy kept at 0°C, at the International Bureau of Weights and Measures near Paris.

The standard meter

Enrichment Information

In 1960, in the General Conference of Weights and Measures, scientists agreed to replace the standard meter which is made of platinum and iridium alloy with an atomic standard meter defined in terms of the wavelength of the red-orange light emitted by the krypton atom 86, which is one of the atomic constants and the atomic standard meter can be defined as a specific number of wavelengths (1650763.73) of the red-orange light emitted in vacuum by the atoms of krypton (mass number 86) contained in discharge tube.



- The atomic standard meter is preferred to the international standard meter because :
  1. It is more accurate where the relative error is as small as few microns (10^{-6}).
  2. It is not affected by environmental conditions.

2 The standard mass (The standard kilogram)

- It is used to calibrate the unit of measuring mass (the kilogram).

The standard kilogram

- **The standard kilogram** is the mass of a cylinder made of platinum and iridium alloy of specific dimensions kept at 0°C, at the International Bureau of Weights and Measures near Paris.

Note :

Platinum and iridium alloy is used in making standard meter and standard kilogram instead of other materials such as glass because platinum and iridium alloy is rigid, chemically inactive and not affected by the surrounding temperature contrary to other materials.

3 The standard time (The second)

In ancient times

The **daytime** and the **night time** were taken to figure out an easy and acceptable measure for the time unit where :

One day = 24 hours, an hour = 60 minutes and a minute = 60 seconds

∴ Second found in the average solar day = 24 × 60 × 60 = 86400 seconds

UNIT 1

Recently

Scientists use the **atomic clocks** such as the cesium clock to calibrate the second because of their high accuracy.

The atomic cesium clock

⊙ **The atomic cesium clock is used for :**

- Determining the duration of the Earth spin (the day length).
- Checking up for the aviation and navigations.
- Verifying the journey schedule of space ships that explore the universe.

Enrichment information

- The scientists defined the second by using the atomic cesium clock as follows : It is the interval of time spent by the cesium atom (atomic mass 133) to emit a certain number of waves, specifically 9192631700 waves.

Dimensional formula

⊙ **Most of the derived physical quantities can be expressed in terms of the dimensions of the fundamental physical quantities which are :**

1. Mass which is denoted by **M**.
2. Length which is denoted by **L**.
3. Time which is denoted by **T**.

, and when we express the physical quantities in terms of the symbols (M , L and T) where each of them has a certain exponent we get the **dimensional formula** of the quantity.

⊙ **The general dimensional formula of any physical quantity is :**

$$[A] = M^{\pm a} L^{\pm b} T^{\pm c}$$

Where : A is the physical quantity, the brackets [ ] is used to express the dimensional formula and (a, b and c) are the exponents of the dimensions (M, L and T) respectively.

How to deduce the dimensional formula

➲ **The following table shows how to deduce the dimensional formula of the velocity (v) as an example :**

	Steps	Example
1	Write down the mathematical relation that determine the given physical quantity.	$v = \frac{\text{Displacement}}{\text{Time}} = \frac{d}{t}$
2	Write down the relation in terms of the fundamental physical quantities (M, L and T).	$[v] = \frac{L}{T}$
3	Put on each of the symbols M, L and T its suitable power. If one of the physical quantities mass, length or time is not present in the formula, it can be expressed as M^0, L^0 or T^0 such that $x^0 = 1$ so it is not written. • The measuring unit can be obtained from the dimensional formula.	$[v] = M^0 L T^{-1}$ $= L T^{-1}$ $m.s^{-1}$ Or m/s

Notes :

1. To add or subtract two physical quantities, they must be of the same kind which means they must have the same dimensional formula and the same unit, **for example :**
   We can't add or subtract mass with distance or velocity with energy.
2. If two quantities have different units, one unit should be converted into the other unit, **for example :**
   1 m + 170 cm = 100 cm + 170 cm = 270 cm
3. We can multiply or divide physical quantities of different dimensional formula. In this case a new physical quantity is obtained, **for example :**
   - By multiplying the velocity and the mass we get a new physical quantity which is the "momentum".
     Velocity (m/s) × Mass (kg) = Momentum (kg.m/s)
   - By dividing the distance over the time we get a new physical quantity which is the "speed".

   $\frac{\text{Distance (m)}}{\text{Time (s)}}$ = Speed (m/s)
4. Dimensional formula **cannot be** added or subtracted but it **can be** multiplied or divided **for example :**
   - $LT^{-1} + LT^{-1} = LT^{-1} \neq 2LT^{-1}$
   - $LT^{-1} - LT^{-1} = LT^{-1} \neq 0$
   - $M \times LT^{-2} = MLT^{-2}$
   - $MLT^{-2} \div M = LT^{-2}$

5. Numerical constants (numerals) **such as** (π , 2 , $\frac{1}{2}$) and trigonometric functions **such as** ($\sin\theta$, $\cos\theta$ and $\tan\theta$) have no dimensions.

➲ The following table shows the dimensional formulae of some derived physical quantities and their measuring units :

The physical quantity	Its relationship to other quantities	The dimensional formula	Unit of measurement
Area	A = Length × Width	$[A] = L \times L = L^2$	m^2
Volume	V = Length × Width × Height	$[V] = L \times L \times L = L^3$	m^3
Density	$\rho = \frac{\text{Mass}}{\text{Volume}}$	$[\rho] = ML^{-3}$	kg/m^3
Velocity	$v = \frac{\text{Displacement}}{\text{Time}}$	$[v] = L T^{-1}$	m/s
Acceleration	$a = \frac{\text{Change of velocity}}{\text{Time}}$	$[a] = L T^{-2}$	m/s^2
Force	F = Mass × Acceleration	$[F] = M \times L T^{-2} = MLT^{-2}$	$kg.m/s^2$ = Newton (N)

Example 1

Find the dimensions and the unit of measuring acceleration, knowing that acceleration is the rate of change of velocity.

Solution

$$\text{Acceleration} = \frac{\text{Change of velocity}}{\text{Time}} = \frac{\text{Displacement / Time}}{\text{Time}}$$

$$\therefore [a] = \frac{L/T}{T} = \frac{L T^{-1}}{T} = L T^{-2}$$

∴ Dimensions of acceleration : $L T^{-2}$

, unit of measuring acceleration : $m.s^{-2}$

Example 2

Find the dimensions and the unit of measuring work (energy), knowing that :
Work = Force × Displacement (W = Fd), Force = Mass × Acceleration (F = ma)

Solution

$W = Fd = mad = m \frac{v}{t} d = m \frac{s/t}{t} d$

$[W] = M \frac{L/T}{T} L = \frac{M L^2 T^{-1}}{T} = M L^2 T^{-2}$

∴ Dimensions of work : ML^2T^{-2}

, unit of measuring work : $kg.m^2.s^{-2}$

Example 3

From the following relation : $X = C_1 + C_2 t$
Find the dimensions and the measuring units of the two quantities C_1 and C_2.
(where : (X) is the distance in meters and (t) is the time in seconds)

Solution

Clue

We can obtain the dimensions of the two quantities by equalizing the dimensions of the two sides of the equation and taking into consideration that the dimensional formula can't be added.

The dimensions of the L.H.S. : [X] = L

∴ The dimensions of each term in the R.H.S. equal L.

∴ $[C_1] = L$, ∴ The measuring unit of C_1 is meter.

∴ $[C_2 t] = L$

∵ $[t] = T$

∴ $[C_2] = \frac{L}{T} = LT^{-1}$, ∴ The measuring unit of C_2 is meter/second.

The importance of the dimensional formula

The dimensional formula can be used to **verify the validity of a physical relation**.
When applying the dimensional analysis, dimensions of both sides of the equation should match.

For Example :

If we have any relation in the form of X = Y, we will have two possibilities :

If

The dimensional formula of X = The dimensional formula of Y	The dimensional formula of X ≠ The dimensional formula of Y
So	
The relation may be correct.	The relation must be wrong.
Where	
Having the same dimensions on both sides of a relation does not mean for sure that the relation is correct.	Different dimensions on both sides of the relation confirms that it is wrong.

Example 1

Verify the following relation by using the dimensional formula :
Kinetic energy = $\frac{1}{2}$ × Mass × Square of velocity ($KE = \frac{1}{2} mv^2$)
, given that the dimensions of energy is ML^2T^{-2}.

Solution

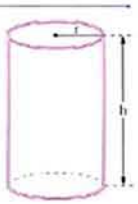
$$KE = \frac{1}{2} mv^2$$

L.H.S. dimensions	R.H.S. dimensions
Dimensions of energy = $M L^2 T^{-2}$	$M (L T^{-1})^2$ = $M L^2 T^{-2}$

∵ The dimensions of both sides are equal.
∴ The relation is possible.

Example 2

Someone has suggested that the cylinder volume can be determined by the relation : $V = \pi rh$, where (r) is the radius of its base and (h) is its height. Use the dimensional formula to verify whether the relation is correct or not.



Solution

$V = \pi r h$

L.H.S. dimensions: L^3

R.H.S. dimensions: $LL = L^2$

∵ The dimensions of both sides aren't equal.

∴ The relation is wrong.

Example 3

The movement of an object under the effect of gravity is given by the relation : $v_f = v_i + g\,t$ Verify the validity this relation using the dimensional analysis, given that (g) is the acceleration due to gravity, (v_f) is the final velocity and (v_i) is the initial velocity.

Solution

$v_f = v_i + gt$

R.H.S. dimensions: LT^{-1}

L.H.S. dimensions: v_i: LT^{-1} ; gt: $LT^{-2}T = LT^{-1}$

∵ The dimensions of both sides are equal.

∴ The relation is possible.

3 Test yourself

If the displacement of a body at an instant is given by :

$$x = 22 + At + B\sqrt{2t}$$

Where : (x) is measured in meters and (t) is measured in seconds.

Find the dimensions of A and B.

.....

.....

.....

.....

QUESTIONS ON
Chapter 1
LESSON ONE

Physical Measurements

Interactive test

First Multiple choice questions

1. The fundamental quantities of the following are .....
   (a) the length and the area (b) the velocity and the acceleration
   (c) the mass and the volume (d) the time and the mass

2. The derived quantities of the following are .....
   (a) velocity - distance - time (b) mass - density - volume
   (c) work - force - distance (d) force - volume - density

3. The suitable tool for measuring the length of a room is .....

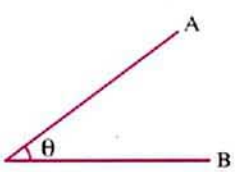
(a) (b) (c) (d)

4. The suitable tool for measuring the mass of a golden ring is .....

(a) (b) (c) (d)

5. A common feature in the French (Gaussian) system, the British system and the Metric system is that they all measure .....
   (a) length in meter (b) mass in pound (c) time in second (d) all the previous

6. From the opposite figure :
   The measuring unit of the angle (θ) in the International system of units is .....
   (a) candela (b) radian
   (c) steradian (d) meter



7. 86.2 cm is equal to .....
   (a) 8.62 m (b) 8.62×10^{-4} km (c) 0.862 mm (d) 862×10^{10} μm

8 Femtosecond = ... microsecond

(a) 10^{-15} (b) 10^{-9} (c) 10^{9} (d) 10^{6}

9 If the volume of an amount of water equals 5 m^3, then the volume in liters equals .....

(a) 5 (b) 50 (c) 500 (d) 5000

10 If the radius of the hydrogen atom is 0.053 nm, then it is equivalent to .....

(a) 0.53×10^{-10} m (b) 5.3×10^{-11} m (c) 53×10^{-12} m (d) all the previous

11 How many bottles of volume 10000 cm^3 is enough to fill a tank of capacity 1 m^3 ? .....

(a) 1 (b) 10 (c) 1000 (d) 100

12 If : x = 10 g and y = 10 kg, then the value of (x + y) is .....

(a) 10.1 kg (b) 100.1 g (c) 10.01 kg (d) 10.01 g

13 If the measuring unit of a physical quantity is kg/m.s^2, then its dimensional formula is .....

(a) MLT (b) $ML^{-1}T^{-2}$ (c) $ML^{-1}T^{2}$ (d) MLT^{2}

14 If the dimensions of the quantity A are ML^2T^{-2} and the dimensions of the quantity B are ML^2T^{-2}, then the dimensions of the quantity (2B – A) are .....

(a) ML^2T^{-2} (b) $M^2L^4T^{-2}$ (c) $M^3L^6T^{-6}$ (d) not defined

15 If x = yz where the dimensions of (x) are MLT^{-2} and the dimensions of (y) are M^0LT^{-2}, so the dimensions of (z) are .....

(a) MLT (b) ML^0T^0 (c) M^0LT (d) $M^{-1}LT$

16 Which row in the following table describes the dimensions of the quantities shown in the table ? .....

(knowing that : the dimensions of x is L^2T^{-2} and the dimensions of y is ML^{-1})

	xy	$\frac{y}{x}$	x + y
(a)	MLT^{-2}	MLT	MLT^{-2}
(b)	MLT^{-2}	$ML^{-3}T^{2}$	MLT
(c)	MLT	MLT^{-1}	can not be added
(d)	MLT^{-2}	$ML^{-3}T^{2}$	can not be added

17 If the dimensions of a physical quantity are $M^xL^xT^{-2x}$ where x is an integer number, so the quantity may be the .....

(a) force (b) acceleration (c) density (d) velocity

UNIT 1

18 The opposite table shows the dimensions of the physical quantities x, y, z and k. Which of the following equations may be correct ? .....

The quantity	x	y	z	k
Dimensional formula	LT^{-1}	LT^{-1}	LT^{-2}	T

(a) $x = y + z + k$ (b) $x = y + z\,k$ (c) $x = y\,z\,k$ (d) $x = \frac{z\,k}{y}$

19 A student measures a current as 0.5 A. Which of the following correctly expresses this result ?.....

(a) 50 mA (b) 50 MA (c) 500 mA (d) 500 MA

20 What is the ratio $\frac{10^{-3}\ THz}{10^{3}\ KHz}$? .....

(a) 10^{-9} (b) 10^{-6} (c) 10^{0} (d) 10^{3}

21 Five values of energy are listed :

5 kJ 5 mJ 5 MJ 5 nJ

Which of the following represents an ascending order of these energies ? .....

(a) 5 kJ → 5 mJ → 5 MJ → 5 nJ (b) 5 nJ → 5 kJ → 5 MJ → 5 mJ

(c) 5 nJ → 5 mJ → 5 kJ → 5 MJ (d) 5 mJ → 5 nJ → 5 kJ → 5 MJ

22 Which product - pair of metric prefixes has the greatest magnitude ? .....

(a) Pico × Mega (b) Nano × Kilo (c) Micro × Giga (d) Milli × Tera

23 Which statement using prefixes of the base unit meter (m) is not correct ? .....

(a) 1 pm = 10^{-12} m (b) 1 nm = 10^{-9} m

(c) 1 Mm = 10^{6} m (d) 1 Gm = 10^{12} m

Second Essay questions

1 Is the physical quantity that is measured by $kg.m^{-3}$ fundamental or derived quantity ? **And why ?**

2 **Arrange in a descending order the following masses :**

(1) 15 g (2) 0.032 kg (3) 2.7×10^{5} mg

(4) 4.1×10^{-8} Gg (5) 2.7×10^{8} µg

3 **What** is the importance of using (platinum - iridium) alloy in the standard meter ?

4 **Is** the following statement valid ? **Explain your answer.**

"The dimensional formula is used to prove that a rule is incorrect, but it is not enough to prove that the rule is correct".

5 The relation ($x = At^2 + Bt$) describes the motion of a body, where the quantity (x) has the dimensions of length and the quantity (t) has the dimensions of time. **Find** the dimensions of A and B.

6 If Newton's universal gravitational law is given by the relation : $F = \frac{GMm}{r^2}$

(where : (F) is the attraction force between two bodies, (M) is the mass of the first body, (m) is the mass of the second body, (r) is the distance between the centers of the two bodies and (G) is the universal gravitational constant).

Find the measuring unit of (G) in the International System of units.

7 The dimensional formula of both quantities X and Y is $L\,T^{-1}$, the dimensional formula of quantity Z is $L\,T^{-2}$ and the dimensional formula of quantity K is L.

Use the previous quantities to form a possible relation.

8 **Use the dimensional formula to verify the following laws :**

(1) Work = $\frac{1}{2}\,mv^2$ **(2)** Volume of a sphere = $\frac{4}{3}\,\pi r^3$

(3) Force = $\frac{\text{Mass}}{\text{Volume}}$ **(4)** Area of a square = ℓ^3

(5) $v = a^2\,t$

Where : (v) is the body's velocity , (m) is the body's mass , (r) is the sphere's radius , (a) is the body's acceleration and (ℓ) is the length of the square.

9 **Deduce the dimensions of each of the following :**

(1) Force. **(2)** Work. **(3)** Pressure.

(knowing that : Force = Mass × Acceleration , Pressure = $\frac{\text{Force}}{\text{Area}}$ and Work = Force × Displacement)

10 **Apply the dimensions of physical quantities to verify the following relations :**

(1) $v_f^2 = v_i^2 + 2\,ad$

(2) $d = v_i\,t + \frac{1}{2}\,at^2$

Where : (d) is the displacement of an object moving at initial velocity (v_i) and speeds up regularly at an acceleration (a) till it reaches a final velocity (v_f) during time (t).

11 If the dimensional formulae of A and B are M and LT^{-1} respectively.

Find the dimensional formula of C if : $C = \frac{3}{2}\,BA^2$

UNIT 1

Third Problems

1. The pyramid shown in the opposite figure contains about 20 million stones, the mass of each stone is about 2.5 ton. **Calculate** the mass of the pyramid in kilograms.

(5×10^{10} kg)

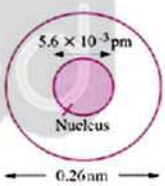
2. The radius of the planet Saturn = 5.85×10^{7} m and its mass = 5.68×10^{26} kg, **calculate :**
   (a) The average density of the planet materials in g/cm^3.
   (b) The surface area of the planet in m^2.
   (knowing that : the volume of a sphere = $\frac{4}{3} \pi r^3$, the area of a sphere = $4 \pi r^2$ and $\pi = \frac{22}{7}$)

(0.677 g/cm^3, 4.3×10^{16} m^2)

3. Cylinder of radius 5 cm and height 20 cm, is made of iron of density 7800 kg/m^3, **find :**
   (a) The volume of the cylinder in m^3.
   (b) The mass of the cylinder in kg. (1.57×10^{-3} m^3, 12.25 kg)

4. If $A = B^n C^m$ and the dimensions of quantities A, B and C are L T, $L^2 T^{-1}$ and $L T^2$ respectively. **Find** the value of m and n. ($\frac{1}{5}$, $\frac{3}{5}$)

5. An atom of gold, in the opposite figure, has a diameter of 0.26 nm and the diameter of its nucleus is 5.6×10^{-3} pm. **Calculate** the ratio of the diameter of the atom to that of the nucleus.



(46.43×10^3)

Chapter 1

LESSON TWO

Types of Measurement & Measurement Error

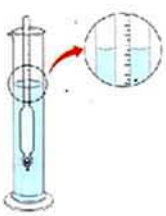
Types of measurement :

1 Direct measurement

- One measuring tool is used.

Examples

1. Measuring the liquid density using the hydrometer in which we take a direct reading without calculation or using any law.



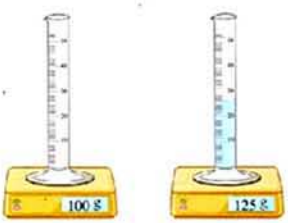
2. Measuring volume using the graduated cylinder.

2 Indirect measurement

- More than one measuring tool are used.

Examples

1. Determining the liquid density via measuring its mass by a balance and its volume by a graduated cylinder. Then, calculating the density from the relation : Density = $\frac{\text{Mass}}{\text{Volume}}$



2. Measuring volume by multiplying length, width and height.

➲ **We can now compare between the two types of measurement as follows :**

Points of Comparison	Direct measurement	Indirect measurement
Number of measuring tools :	One measuring tool is used.	More than one measuring tool is used.
Number of measuring processes :	One measurement process.	More than one measurement process.
Mathematical relations :	No mathematical relation is applied.	A mathematical relation is applied to find the quantity.
No. of measurement errors :	One measurement error.	More than one measurement error (cumulative error).

Error in measurements :

⊙ While carrying out a measurement process, there must be an error even if it is a small percentage of error. So no measurement process is accurate 100% because of several reasons of measurement error, from which :

1. Choosing improper tool, for example :

Using the common balance instead of the sensitive balance in measuring the mass of a golden ring increases the percentage of measurement error.

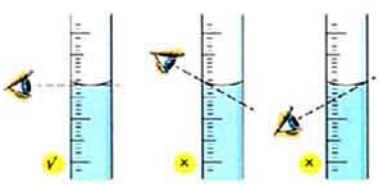
2. A defect in the measuring tool as the defects that may be in the ammeter, for example :

- The magnet inside is partially demagnetized because it is outdated.
- The pointer has a zero error when there is no electric current.

Ammeter

3. Wrong procedure due to unexperienced persons, for example :

- Ignorance of using graduated devices like the multimeters.
- Looking at the device pointer or the scale at an oblique line instead of being perpendicular to the scale.



4. Environmental conditions, for example :

- Temperature.
- Humidity.
- Air currents, because when using the sensitive balance, the air currents may cause an error and to avoid this the sensitive balance is kept inside a glass box.

Glass box to avoid wind effect

Note :

- When carrying out a measuring process, it's preferable to repeat the measurement many times and calculate the average to **reduce** the error percentage in measurement.

Estimating error of measurement :

⊙ **The error in measurement is estimated by calculating :**

① Absolute error (ΔX)	② Relative error (r)
It is the difference between the real (actual) value (X_o) and the measured value (X).	It is the ratio between the absolute error (ΔX) and the real value (X_o).
Rule	
$\Delta X = \lvert X_o - X \rvert$	$r = \frac{\Delta X}{X_o}$
Measuring unit	
Has a measuring unit which is the same measuring unit of the physical quantity.	Has no measuring unit because it is the ratio between two quantities having the same measuring unit.
Notes	
The sign of modulus | | indicates that the result is always **positive** even if the actual value is less than the measured value because the aim of estimating the absolute error is only knowing its value.	The relative error is **a better indication** for the measurement accuracy than the absolute error because it is the ratio between the absolute error and the real value. The measurement accuracy is considered **higher** as the relative error **decreases.**

⊙ **The result of measurement is expressed as ($X_o \pm \Delta X$).**

⊙ Now, we will know how to calculate the absolute error and the relative error in case of direct and indirect measurement processes.

UNIT 1

1 Estimating error in direct measurement

- The absolute error is directly calculated from the relation :

$$\Delta X = | X_o - X |$$

- The relative error is directly calculated from the relation :

$$r = \frac{\Delta X}{X_o} = \frac{| X_o - X |}{X_o}$$

Example

A student measured the length of a pencil and found it equal to 9.9 cm, meanwhile its actual length is 10 cm. Another student measured the classroom length and found it equal to 9.13 m, meanwhile its actual length is 9.11 m.

(a) Estimate the absolute error and the relative error in each case and express the result of measurement.

(b) In which case was the measurement more accurate ? And why ?

Solution

(a)

First student	Second student
Absolute error	
$\Delta X = \lvert X_o - X \rvert$	$\Delta X = \lvert X_o - X \rvert$
$= \lvert 10 - 9.9 \rvert$	$= \lvert 9.11 - 9.13 \rvert$
$= 0.1$ cm	$= \lvert -0.02 \rvert = 0.02$ m
Relative error	
$r = \frac{\Delta X}{X_o}$	$r = \frac{\Delta X}{X_o}$
$= \frac{0.1}{10} = 0.01 = 1\%$	$= \frac{0.02}{9.11} = 0.0022 = 0.22\ \%$
Expressing the result of measurement	
The length of the pencil $= (10 \pm 0.1)$ cm	The length of the classroom $= (9.11 \pm 0.02)$ m

(b) The measurement in the second case is more accurate because the relative error in the second case is less than that in the first case.

2 Estimating error in case of indirect measurement

The procedure of calculating error in case of indirect measurement depends on the mathematical operation applied as shown in the following table :

Mathematical operation	Example	How to calculate error
Summation ⊕	Measuring the volume of two amounts of a liquid. $V = V_1 + V_2$	• The absolute error = The absolute error in first measurement + The absolute error in second measurement $\Delta X = \Delta X_1 + \Delta X_2$ $= \lvert X_{o1} - X_1 \rvert + \lvert X_{o2} - X_2 \rvert$ • The relative error (r) = $\frac{\text{The absolute error}}{\text{The real value}}$ $r = \frac{\Delta X}{X_o}$
Subtraction ⊖	Finding the volume of a coin by subtracting the volume of water before dropping the coin into the measuring cylinder (V_1) from that after dropping it (V_2). $V_{coin} = V_2 - V_1$	
Multiplication ⊗	Finding the area of a rectangle by measuring its length and its width then multiplying them.	• The relative error = The relative error in first measurement + The relative error in second measurement $r = r_1 + r_2$ $= \frac{\Delta X_1}{X_{o1}} + \frac{\Delta X_2}{X_{o2}}$ • The absolute error (ΔX) = The relative error × The real value $\Delta X = r X_o$
Division ÷	Finding the density of a liquid by measuring its mass and its volume then dividing them.	

Example 1

In a practical experiment to determine a physical quantity (L) by adding two physical quantities L_1 and L_2 given that $L_1 = (5.2 \pm 0.1)$ cm and $L_2 = (5.8 \pm 0.2)$ cm.
Find the value of (L) and the relative error in measuring it.

Solution

$\because$ The real value of (L) : $L_o = 5.2 + 5.8 = 11$ cm

$\because$ The absolute error : $\Delta L = 0.1 + 0.2 = 0.3$ cm

$\therefore$ The value of (L) : $L = (L_o \pm \Delta L) = (11 \pm 0.3)$ cm

$\therefore$ The relative error : $r = \frac{\Delta L}{L_o} = \frac{0.3}{11} = \frac{3}{110}$

Example 2

A student measured the mass of an amount of a chemical material, it was found to be (20 ±0.1) g then the mass of the material was decreased by (5 ±0.1) g. Calculate the mass of the remaining amount of the material and the relative error in measuring the remaining amount.

Solution

$m_o = 20 - 5 = 15$ g

$\Delta m = 0.1 + 0.1 = 0.2$ g

$m = (m_o \pm \Delta m) = (15 \pm 0.2)$ g

$r = \frac{\Delta m}{m_o} = \frac{0.2}{15} = \frac{1}{75}$

Example 3

Calculate each of the relative error and the absolute error when measuring the area of a rectangle (A) that has a length of (6 ± 0.1) m and a width of (5 ± 0.2) m.

Solution

Clue

The area of the rectangle (A) is determined by multiplying the length (x) by the width (y) so the measurement process is indirect. We can find the relative error in measuring the area of the rectangle from the relation :

$$r_A = r_x + r_y \quad , \quad r_x = \frac{\Delta x}{x_o} \quad , \quad r_y = \frac{\Delta y}{y_o}$$

, and also we can calculate the absolute error in measuring the area of the rectangle from the relation : $\Delta A = r_A A_o$

∵ The relative error in measuring :

The length	The width
$r_x = \frac{0.1}{6}$	$r_y = \frac{0.2}{5}$

∴ The relative error in measuring the area :

$$r_A = \frac{0.1}{6} + \frac{0.2}{5} = \frac{17}{300}$$

∴ The absolute error in measuring the area :

$$\Delta A = \left(\frac{17}{300}\right) \times (5 \times 6) = 1.7 \text{ m}^2$$

Example 4

Calculate the relative error and the absolute error when measuring the volume of a cuboid where its dimensions are as follows :

Dimension	Measured value (cm)	Actual value (cm)
Length (x)	4.3	4.4
Width (y)	3.3	3.5
Height (z)	2.8	3

Solution

Clue

The volume of a cuboid is determined by multiplying (the length (x) × the width (y) × the height (z)), so the measurement process is indirect. The relative error and the absolute error in measuring the volume of the cuboid can be calculated as follows :

$$r = r_x + r_y + r_z \quad , \quad r_x = \frac{\Delta x}{x_o} \quad , \quad r_y = \frac{\Delta y}{y_o} \quad , \quad r_z = \frac{\Delta z}{z_o}$$

$$\Delta V = r V_o \quad , \quad V_o = x_o y_o z_o$$

The relative error in measuring :

The length	The width	The height
$r_x = \frac{\lvert 4.4 - 4.3 \rvert}{4.4} = \frac{1}{44}$	$r_y = \frac{\lvert 3.5 - 3.3 \rvert}{3.5} = \frac{2}{35}$	$r_z = \frac{\lvert 3 - 2.8 \rvert}{3} = \frac{1}{15}$

The relative error in measuring the volume :

$$r = \frac{1}{44} + \frac{2}{35} + \frac{1}{15} = 0.1465$$

The absolute error in measuring the volume :

$$V_o = 4.4 \times 3.5 \times 3 = 46.2 \text{ cm}^3$$

$$\Delta V = 0.1465 \times 46.2 = 6.77 \text{ cm}^3$$

UNIT 1

Example 5

An object has a mass of (2000 ± 10) kg and a volume of (0.1 ± 0.001) m^3
Calculate its density.
(knowing that : Density (ρ) = $\frac{Mass\ (m)}{Volume\ (V)}$)

Solution

The relative error in measuring the mass :

$$r_1 = \frac{\Delta m}{m_o} = \frac{10}{2000} = \frac{1}{200}$$

The relative error in measuring the volume :

$$r_2 = \frac{\Delta V}{V_o} = \frac{0.001}{0.1} = \frac{1}{100}$$

The relative error in measuring the density :

$$r = r_1 + r_2 = \frac{1}{200} + \frac{1}{100} = \frac{3}{200}$$

$$\rho_o = \frac{m_o}{V_o} = \frac{2000}{0.1} = 2 \times 10^4 \text{ kg/m}^3$$

$$\Delta\rho = r\,\rho_o = \frac{3}{200} \times 2 \times 10^4 = 300 \text{ kg/m}^3$$

$$\therefore \rho = (2 \times 10^4 \pm 300) \text{ kg/m}^3$$

Test yourself

A body of mass (5 ± 0.5) kg moves by a velocity of (2 ± 0.2) m/s. **Calculate** the relative error and the absolute error in measuring the kinetic energy of the body.
(knowing that : The kinetic energy of the body = $\frac{1}{2}$ mv^2)

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Enrichment information

Hallmark and balances department (bureau) is considered as an expert office in Egypt to assay and calibrate weighing scales, measuring tools and bushels.
It is also concerned with supervision and inspection. It has 54 branches all over the country.

QUESTIONS ON

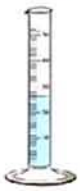
Chapter 1

LESSON TWO

Types of Measurement & Measurement Error

Interactive test

First Multiple choice questions



1. The measurement process shown in the opposite figure is considered as a ..... measurement.
   (a) complex (b) complicated (c) direct (d) indirect

2. The best way to judge the accuracy of measurement is through .....
   (a) the absolute error
   (b) the relative error
   (c) the product of the relative error and the absolute error
   (d) all of them

3. The opposite figure shows an ammeter when there is no electric current passing through it, then which of the following figures describes the ammeter when a current of intensity 3 A passes through it ? .....

(a) (b) (c) (d)

4. A golden ring of mass 6.32 g was placed on several sensitive balances as in the following figures, which one of them is the most accurate in measuring ? .....

(a) (b) (c) (d)

5. When measuring the current intensity in a circuit, the intensity was expected to be 2 A, so which of the following ammeters is the most appropriate for measuring the current accurately? .....

(a) (b) (c) (d)

6 The relative error in measuring the area of a room is 0.06 where the actual value of the area is 30 m^2, then the absolute error in measuring this area is .....

(a) 1.8 m^2 (b) 0.002 m^2 (c) 0.06 m^2 (d) 1.2 m^2

7 A student measured the length of a wooden bar which is found to be 50.2 cm, while the actual value is 50 cm. Accordingly,

(i) The absolute error = ...

(a) 50 cm (b) 2 cm (c) 0.2 cm (d) 0.04 cm

(ii) The relative error = ...

(a) 50 % (b) 10 % (c) 2 % (d) 0.4 %

8 A student measured the length of a classroom by using a meter tape, he finds that the length equals (10 ± 0.1) m , then .....

	Type of measurement	Absolute error	Relative error
(a)	Direct	10 m	0.01
(b)	Direct	0.1 m	0.01
(c)	Indirect	10 m	0.001
(d)	Indirect	0.1 m	10.1

9 If : x = (1 ± 0.01) kg and y = (50 ± 1) g, then (x + y) equals .....

(a) (1050 ± 1.01) g (b) (1.05 ± 1.01) kg (c) (50.1 ± 1.01) g (d) (1.05 ± 0.011) kg

10 If rod A has a length of (2.35 ± 0.01) cm and rod B has a length of (5.68 ± 0.01) cm , then rod B is longer than rod A by .....

(a) (3.33 ± 0.00) cm (b) (3.33 ± 0.02) cm

(c) (2.43 ± 0.01) cm (d) (2.43 ± 0.001) cm

11 If the mass of a body is (10 ± 1) kg and its velocity is (4 ± 0.04) m/s, then its momentum equals ..... .

(knowing that : Momentum = Mass × Velocity)

(a) (40 ± 1.4) kg.m/s (b) (14 ± 4.4) kg.m/s

(c) (40 ± 4.4) kg.m/s (d) (14 ± 1.4) kg.m/s

12 A student measured some physical quantities in his room and he gets the following results, so which of them is more accurate ? .....

	The physical quantity	Its value
(a)	The room length	(6 ± 0.05) m
(b)	The room width	(4 ± 0.05) m
(c)	The room height	(3.5 ± 0.05) m
(d)	The room temperature	$(30 \pm 0.5)\ ^{\circ}C$

Second Essay questions

1 **State the precautions considered when using :**

(1) The metric ruler to measure the length of an object.

(2) The ammeter when measuring the electric current intensity.

(3) The graduated cylinder when measuring the volume of a liquid.

(4) The sensitive balance.

2 **Explain the following sentences :**

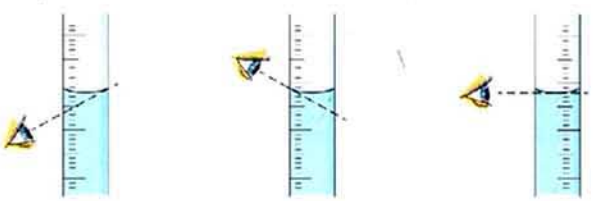
(1) The value of absolute error is always positive.

(2) The relative error has no measuring unit.

(3) The relative error is a better indicator for measurement accuracy than the absolute error.

3 When students were measuring the mass of a piece of iron in the Physics lab, the teacher asked them to repeat the measurement process several times and calculate the average. **What** is the purpose of the teacher's demand ?

4 **Which** of the following ways is the right way to measure the volume of the water in a graduated cylinder ? **And why** ?



(1) (2) (3)

5 Four friends was measuring four different physical quantities and their results were as follows :

(a) (10 ± 0.1) cm (b) (1 ± 0.01) m

(c) (50 ± 0.5) kg (d) (200 ± 0.02) s

Arrange these measurements in ascending order according to their accuracy.

Third Problems

1 An engineer measured the length of a building which was equal to 55.2 m. If there was an error of 0.02 m, **what** are the probabilities of the real value of the building length?

(55.22 m, 55.18 m)

2 The solar year is approximately equal to $\pi \times 10^7$ s, **find** the percentage of error in this approximation. (knowing that : The solar year = 365.25 days) (0.4 %)

3 **Find** the relative error in estimating the volume of a cube of side length 5 cm given that the relative error in estimating its length is 0.01, **then find** the absolute error in this case.

(0.03, 3.75 cm^3)

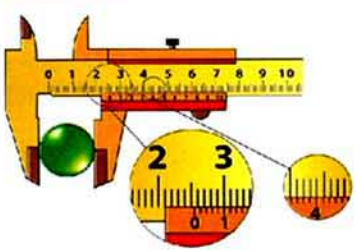
4 On estimating the density of an object, the mass was (40 ± 0.2) kg and the volume was (0.5 ± 0.01) m^3. **Find** the absolute error and the relative error in measuring the density. (knowing that : Density = $\frac{\text{Mass}}{\text{Volume}}$) (0.025 , 2 kg/m^3)

5 If $x = (5 \pm 0.1)$ cm and $y = (10 \pm 0.2)$ cm, **calculate each of :**

(a) $x + y$ (b) $2x + y$ (c) xy (d) xy^2

((15 ± 0.3) cm, (20 ± 0.4) cm, (50 ± 2) cm^2, (500 ± 30) cm^3)

6 The vernier caliper was used to measure the diameter of a metallic ball as shown in the opposite figure.



Find from the opposite figure :

(a) The measured value by using this tool.

(b) The absolute error and the relative error in this measurement, if the actual value of the diameter is 2.53 cm.

(c) **Express** the result of measurement. (2.54 cm, 0.01 cm, 0.4 %, (2.53 ± 0.01) cm)

7 The exact value of the area of a piece of land is 200.2 m^2. The shown meter ruler in figure was used to measure length. Accordingly, an error in measurement took place where the relative error was 0.1 %. **Find** the value of the area when measured.

(199.9998 m^2, 200.4002 m^2)

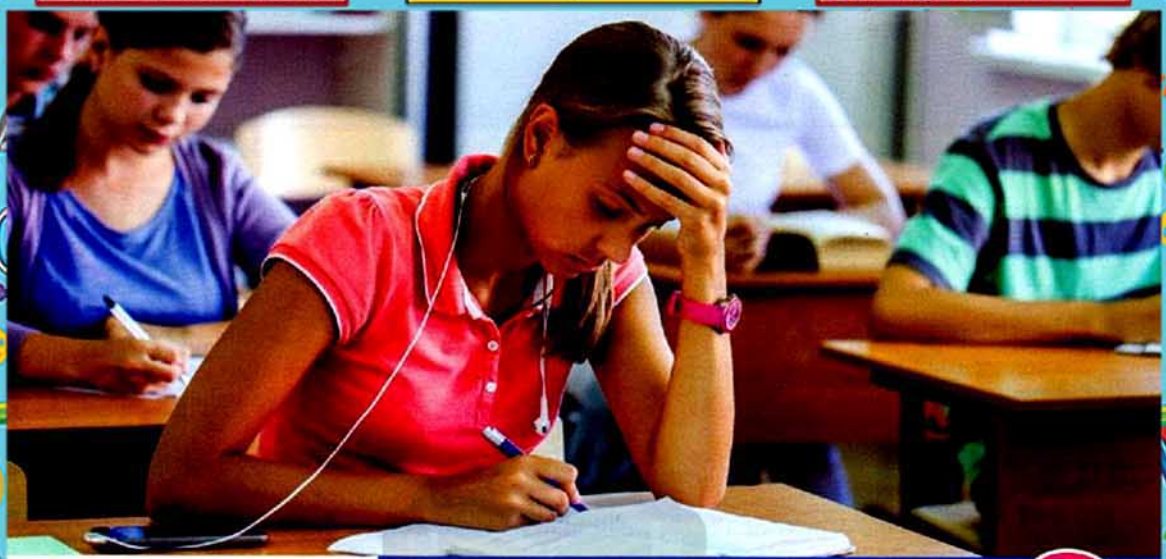
---

8 To measure the density of a cube, we need to measure its mass and the length of one of its sides. If the relative error in measuring its mass is 1.5 % and the relative error in measuring the length of one of its sides is 1 %, **calculate** the relative error in measuring its density. (knowing that : Density = $\frac{\text{Mass}}{\text{Volume}}$) (4.5 %)

---

9 A uniform solid sphere of radius (6.5 ± 0.2) cm and mass (1.85 ± 0.02) kg. **Calculate** the density of the sphere in kg/m^3. (knowing that : Density = $\frac{\text{Mass}}{\text{Volume}}$)

(1.61 ± 0.17) × 10^3 kg/m^3)



MODEL EXAM ON

Chapter 1

Physical Measurements

First Choose the correct answer

1. The suitable tool for measuring the thickness of a thin sheet is .....

(a) (b) (c) (d)

2. The mass of a cube and the length of one of its sides were measured, where the relative error in measuring its mass was 2 % and the relative error in measuring its side's length was 1.5 %, then the relative error in measuring its density is .....

(knowing that : Density = $\frac{\text{Mass}}{\text{Volume}}$)

(a) 0.5 % (b) 3.5 % (c) 6.5 % (d) 9.5 %

3. If the radius of a virus is 5.1 nm, then the diameter of the virus equals .....

(a) 10.2×10^{-3} μm (b) 1.02×10^{-7} mm

(c) 10.2×10^{-8} m (d) all the previous

4. If the dimensional formula of a physical quantity is $M^x L^x T^{x-3}$ where x is an integer number, then this quantity may be the .....

(a) force (b) acceleration (c) work (d) velocity

5 An empty large box of mass (20 ± 0.01) kg, when a man sits inside the box, the mass of the box and the man together become (0.1 ± 0.001) ton, so the mass of the man is .....

(a) (120 ± 0.009) kg (b) (0.12 ± 0.011) ton

(c) (80 ± 1.01) kg (d) (80 ± 0.99) ton

6 If the dimensional formula of a physical quantity is $M L T^{-1}$, then its measuring unit is .....

(a) kg.m.s (b) $kg.m.s^{-1}$ (c) $kg.m^{-1}.s^{-1}$ (d) $kg.m^{-1}.s$

7 How many bottles of volume 1000 cm^3 are needed to fill a tank of volume 1 m^3 ? .....

(a) 1 (b) 10 (c) 1000 (d) 100

8 If the dimensions of quantity x are $M^0 L^0 T$ and the dimensions of quantity y are $M L T^{-1}$, then the dimensions $M L T^{-2}$ describe the quantity .....

(a) x y (b) $x y^2$ (c) $\frac{x}{y}$ (d) $\frac{y}{x}$

9 The length of a rectangle was measured to be (6 ± 0.01) cm and its width was measured to be (4 ± 0.01) cm, then the percentage of error in measuring the perimeter of the rectangle is .....

(a) 0.2 % (b) 0.4 % (c) 0.1 % (d) 2 %

10 If the dimensions of A are $L^2 T$ and the dimensions of B are $L T^2$, then the dimensions of $A - 3B$ are .....

(a) $L^3 T^3$ (b) $L T$ (c) $L^2 T^2$ (d) not defined

Second Answer the following questions

11 **Why** is not the glass used in manufacturing the standard meter ?

.....

.....

.....

12 By using the dimensional formula of physical quantities, **check** the validity of the following relation : $F = m a^2$

(knowing that : (F) is the force, (m) is the mass, (a) is the acceleration)

.....

.....

.....

13 "The absolute error is the best indicator for measurement accuracy"
Discuss the validity of the previous sentence.

.....

.....

.....

14 **Arrange the following lengths in a descending order :**

(1) 12 m **(2)** 0.07 km **(3)** 2.7×10^{4} mm

(4) 7.2×10^{-9} Gm **(5)** 12×10^{7} µm

.....

.....

.....

15 If the equation ($d = xv + \frac{1}{2} a y^2$) describes the motion of a body, where (d) has the dimensional formula of the length, (v) has the dimensional formula of the velocity and (a) has the dimensional formula of the acceleration.
Find the dimensions of both x and y.

.....

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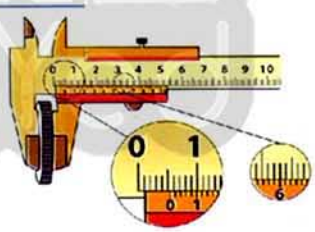
16 The vernier caliper was used to measure the thickness of a metallic coin as shown in the opposite figure. **From the figure find :**



(a) The measured value of the coin's thickness.

(b) The absolute and the relative error in this measurement, if the actual value of the thickness is 5.3 mm.

.....

.....

.....

17 If $A = \frac{3}{2} B^m C^n$ and the dimensions of quantities A, B and C are $L^2 T^2$, $L T^{-1}$ and $L T^2$ respectively. **Find** the values of m and n.

.....

.....

.....

Chapter 2 Scalar and Vector Quantities

⊙ **When measuring a physical quantity like :**

Temperature	Velocity
Its magnitude say 27°C is enough to describe the temperature fully, because we mentioned its magnitude and its measuring unit.	Its magnitude say 50 km/h isn't enough to describe the velocity fully, because we mention its magnitude and its measuring unit but we didn't mention its direction.

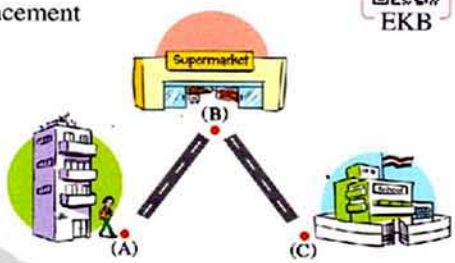
Accordingly, physical quantities can be classified into :

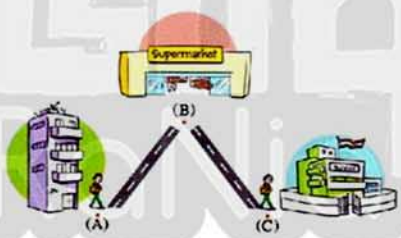
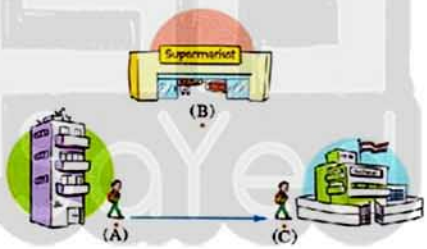
❶ Scalar quantities	❷ Vector quantities
It is a physical quantity that can be fully defined by its magnitude only. It has no direction.	It is a physical quantity that can be fully defined by both magnitude and direction.
Examples	
• Distance. • Mass. • Time. • Temperature. • Energy.	• Displacement. • Velocity. • Acceleration. • Force.

Distance and Displacement

EKB

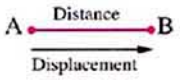
⊙ There is a difference between the concept of displacement and the concept of distance.
This can be clarified through the next example :
The opposite figure shows a student who starts his motion from the home **(point A)** till he reaches the school **(point C)** passing by the supermarket **(point B)**, then :



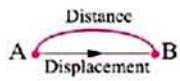
1 Distance (s)	2 Displacement (d)
Is represented by	
The length of the path ($\overline{AB} + \overline{BC}$) which is covered by the student from the home (A) to the school (C) passing by the supermarket (B).	The length of the straight line $\overline{AC}$ from the home (A) to the school (C) directly.
	
Thus	
Distance is the length of the path moved by an object from a position to another.	**Displacement** is given by the length of the straight line segment (shortest distance) in a given direction between the starting point of motion and the end point.
Distance is a **scalar quantity** because it can be fully defined by its magnitude only.	Displacement is **a vector quantity** because it can be fully defined by its magnitude and direction.
Distance is always positive.	Displacement may be positive, negative or zero.

Guidelines to solve problems

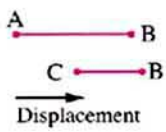
1. If an object moves in one direction (a straight line) from A to B, the magnitude of displacement equals the covered distance.



2. If an object moves in a curved path (any path that isn't in a shape of straight line) from A to B, the magnitude of the displacement will be less than the distance.



3. If an object moves in one direction from A to B, then reverses its direction to C, then :
   - The displacement (d) = $\overline{AB} - \overline{BC}$
   - The distance (s) = $\overline{AB} + \overline{BC}$



4. If an object moves in one direction from A to B then returns back to A, the magnitude of displacement = 0 and the distance covered = 2 $\overline{AB}$

Example 1

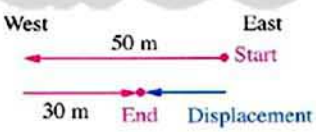
An athlete has moved to west through a displacement of (50 m), then moved back to east through a displacement of (30 m). Calculate the distance covered and the displacement of the athlete.

Solution

The covered distance : s = 50 + 30 = 80 m

The displacement of the athlete : d = + 50 – 30 = + 20 m

∴ The athlete displaced 20 m to west.



Example 2

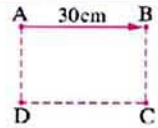
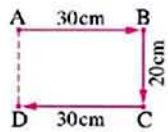
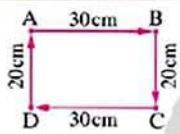
A rectangle (ABCD) is of length 30 cm and width 20 cm. Find the distance and the displacement covered by an object moving along its perimeter in the following cases :

(a) The object moves from (A) to (B).

(b) The object moves from (A) to (D) passing by the points (B) and (C).

(c) The object moves from (A) passing by the points (B), (C) and (D) returning back to (A). What do you conclude in each case ?

Solution

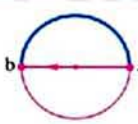
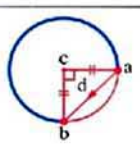
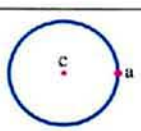
	Path of object	Distance moved	Displacement	Conclusion
(a)		s = 30 cm	d = 30 cm in the direction of $\overrightarrow{AB}$	Displacement (d) = Distance (s) Because the object moves in one direction.
(b)		s = 30 + 20 + 30 = 80 cm	d = 20 cm in the direction of $\overrightarrow{AD}$	Displacement (d) = The shortest length of the line segment between the starting point (A) and the end point (D).
(c)		s = 30 + 20 + 30 + 20 = 100 cm	d = zero	Displacement (d) = 0 Because the starting point (A) is the end point itself.

Example 3

An object moves along the circumference of a circle of radius 2 cm. Find the distance and the displacement covered by the object when it moves :

(a) $\frac{1}{2}$ revolution. *(b)* $\frac{3}{4}$ revolution. *(c)* a complete revolution.

Solution

	Path of object	Distance (s)	Displacement (d)
(a)		$s = \frac{1}{2}(2\pi r) = \frac{22}{7} \times 2 = \frac{44}{7}$ cm	d = 2 r = 2 × 2 = 4 cm in the direction from a to b.
(b)		$s = \frac{3}{4}(2\pi r) = \frac{3}{4} \times \frac{22}{7} \times 2 = \frac{66}{7}$ cm	From Pythagoras theorem : $d = \sqrt{(ca)^2 + (bc)^2} = \sqrt{(2)^2 + (2)^2} = 2\sqrt{2}$ cm in the direction from a to b.
(c)		$s = 2\pi r = 2 \times \frac{22}{7} \times 2 = \frac{88}{7}$ cm	d = zero , because its starting point is exactly its end point.

Notes :

- **When a body moves in a circular path, then :**
  1. The magnitude of its displacement when it moves $\frac{1}{4}$ revolution = The magnitude of its displacement when it moves $\frac{3}{4}$ revolution
  2. Its displacement when it moves $\frac{1}{4}$ revolution ≠ Its displacement when it moves $\frac{3}{4}$ revolution, because the displacement is a vector quantity defined by its magnitude and direction.

Test yourself

Can the magnitude of the displacement of a moving body be greater than the distance covered by the body ? **Explain your answer.**

.....

.....

Representation of vector quantities

EKB

⊙ **The vector quantity is represented by a directed straight segment (⟶) whose base is at the starting point and its tip is at the end point where :**

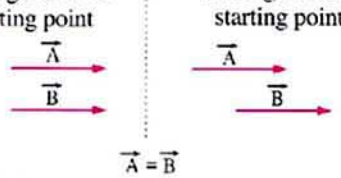
- Its length is proportional to the vector **magnitude.**
- The arrow direction points to the **direction** of the vector quantity.
- The vector quantity is denoted by a bold letter (**A**) or a letter tagged by a small arrow ($\vec{A}$).

⊙ Two vectors may be equal or not according to their magnitudes and the direction of each of them as follows :

Two vectors are equal when they have :

- The same magnitude.
- The same direction.

(even if they have different starting points)



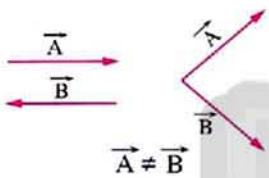
UNIT 1

Two vectors are not equal when they have :

Or

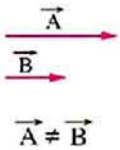
Different directions :

(even if they have the same magnitude)



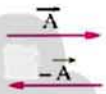
Different magnitudes :

(even if they have the same direction)



Note :

- Vector $(-\vec{A})$ has a magnitude which is equal to the magnitude of vector $(\vec{A})$ but opposite in direction.

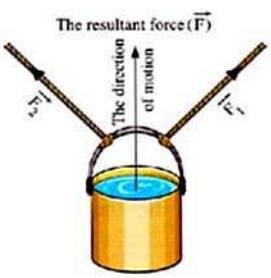


Vectors Algebra

- First: Resultant (addition) of vectors
- Second: Resolution of a vector
- Third: Product of vectors
  - 1 Scalar (dot) product
  - 2 Cross product

First Resultant (addition) of vectors

⊙ When two forces or more act on an object (as in the opposite figure), this object will move in a certain direction determined by the resultant of the forces acting on the object which is called the **resultant force** $(\vec{F})$ which is a single force that produces the same effect on an object as that produced by the original acting forces.



Application :

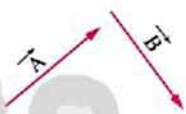
- If two forces of magnitudes **300 N** and **400 N** act on a car in the same direction, the car will move a certain distance during a certain time.

- If the two forces is replaced by a force of magnitude **700 N**, the car will move the same distance during the same time as in the first case when it was affected by the two forces.

This means that : The **700 N** force makes the same effect on the car as the two forces **300 N**, **400 N** therefore it is the resultant of these two forces.

How to add two vectors :

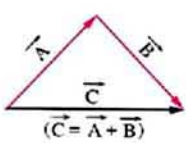
- If there is two vectors as in the opposite figure, they can be added by two methods as follows :



1 By drawing a triangle :

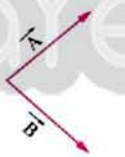
1. Move one of the two vectors without changing its direction or magnitude, to make the end point of one of them at the same point of starting the other.

2. Join the starting point of vector $\vec{A}$ with the end point of vector $\vec{B}$ so the vector $\vec{C}$ will represent the resultant vector which has a direction from the starting point of $\vec{A}$ to the end point of $\vec{B}$.

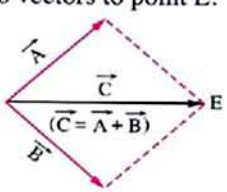


2 By drawing a parallelogram :

1. Move one of the two vectors without changing its direction or magnitude, to make the two vectors have the same starting point.



2. Draw two sides (parallel to the vectors $\vec{A}$ and $\vec{B}$) that complete the shape of the parallelogram where the diagonal represents the resultant vector $\vec{C}$ that have a direction from the starting point of the two vectors to point E.

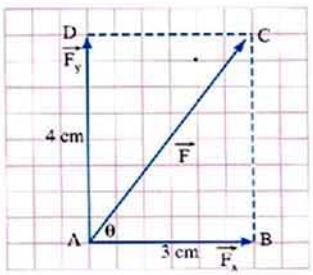


UNIT 1

Finding the resultant of two perpendicular vectors

1 Graphically :

If the two vectors equal 3 N and 4 N :



1. Draw a horizontal line (AB), on the graph paper, of length 3 cm to represent the first vector (F_x = 3 N).
2. Perpendicular to (AB) at the point (A), draw a vertical line (AD) of length 4 cm to represent the second vector (F_y = 4 N).
3. Complete the rectangle ABCD.
4. Join the diagonal (AC) to represent the magnitude and direction of the resultant ($\vec{F}$).
5. Measure the length of the line segment (AC) that represents the magnitude of the resultant.
6. Measure the angle θ (B$\hat{A}$C) that defines the direction of the resultant relative to the first vector (F_x).

2 Theoretically :

1. Find the magnitude of the resultant using Pythagoras' theorem for the right angled triangle : $(\overline{AC})^2 = (\overline{AB})^2 + (\overline{BC})^2$

$\therefore F^2 = F_x^2 + F_y^2$, $F = \sqrt{F_x^2 + F_y^2}$

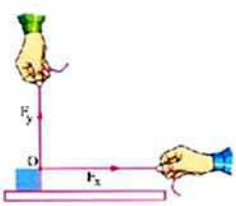
2. We can find the angle (θ) by the relation : $\tan\theta = \frac{\text{Opposite}}{\text{Adjacent}} = \frac{F_y}{F_x}$

Note :

$\vec{A} - \vec{B} = \vec{A} + (-\vec{B})$

Example

Find the resultant of two forces; one of them acts in the direction of x-axis (F_x = 4 N), while the other acts in the direction of y-axis (F_y = 3 N) as shown in the figure, then find the angle which is made by the resultant with x-axis.



Solution

Complete the shape of parallelogram. A rectangle is obtained since the two forces are perpendicular to each other. Thus, the diagonal represents the resultant $\vec{F}$ as shown.

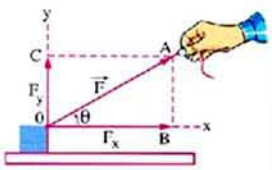
Applying Pythagoras' theorem :

$$F^2 = F_x^2 + F_y^2$$

$$F = \sqrt{F_x^2 + F_y^2} = \sqrt{16 + 9} = \sqrt{25} = 5 \text{ N}$$

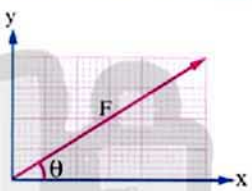
$$\tan \theta = \frac{F_y}{F_x} = \frac{3}{4}$$

$$\theta = 36.87°$$

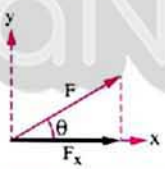


Second Resolution of a vector

⊙ Resolution of a vector is the reverse operation for getting the resultant of perpendicular vectors where a force can be resolved into two perpendicular forces along dimensions (x , y); thus :



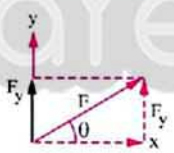
1 **(F_x) the force component in x-axis direction (horizontal component).**



$$\cos \theta = \frac{\text{Adjacent}}{\text{Hypotenuse}} = \frac{F_x}{F}$$

$$F_x = F \cos \theta$$

2 **(F_y) the force component in y-axis direction (vertical component).**

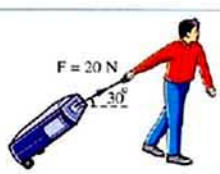


$$\sin \theta = \frac{\text{Opposite}}{\text{Hypotenuse}} = \frac{F_y}{F}$$

$$F_y = F \sin \theta$$

Example 1

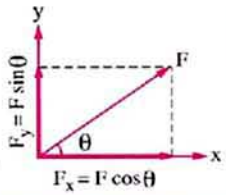
A man pulls a bag by a rope using a force of 20 N in a direction that makes an angle 30° with the horizontal. Find the force components in each of x and y dimensions.



Solution

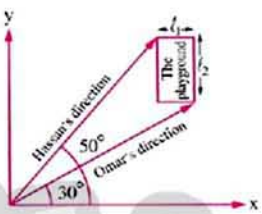
$F_x = F \cos \theta = 20 \cos 30° = 17.3$ N

$F_y = F \sin \theta = 20 \sin 30° = 10$ N



Example 2

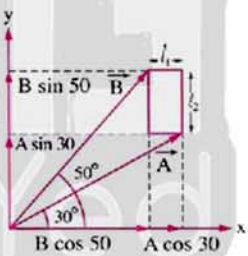
Hassan starts his motion with Omar from the same starting point to reach a soccer playground of rectangular shape. If Hassan covered a displacement of 150 m and Omar covered a displacement of 120 m, calculate the area of the playground.



Solution

Clue

We can find the length and the width of the playground by resolving the displacements of Hassan and Omar.



$\ell_1 = A \cos 30 - B \cos 50$

$= 120 \cos 30 - 150 \cos 50 = 7.5$ m

$\ell_2 = B \sin 50 - A \sin 30$

$= 150 \sin 50 - 120 \sin 30 = 54.9$ m

The area of the playground $= \ell_1 \ell_2 = 7.5 \times 54.9 = 411.75$ m^2

Test yourself

A man covered a distance of 3.1 km with an angle of 25° in the northern east direction. **What** is the displacement that should be covered by the man into north then into east to reach the same point ?

.....

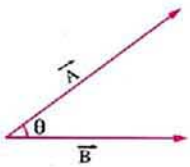
.....

Third Product of vectors

⊙ **There are different forms of finding the product of two vectors :**

1 Scalar (dot) product

* The dot product of two vectors $\vec{A}$ and $\vec{B}$ is expressed as follows :



$$\vec{A} \cdot \vec{B} = AB \cos \theta$$

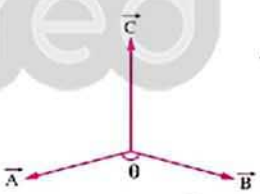
Where : A is the numerical value of vector $\vec{A}$, B is the numerical value of vector $\vec{B}$, θ is the angle between the vectors $\vec{A}$ and $\vec{B}$, the sign (·) is pronounced "dot" and the result is a scalar quantity.

If the angle between the two vectors $\vec{A}$ and $\vec{B}$:

$\theta = 0°$	$\theta = 90°$
Then	
$\vec{A} \cdot \vec{B} = AB \cos 0$	$\vec{A} \cdot \vec{B} = AB \cos 90$
$\vec{A} \cdot \vec{B} = AB$ (maximum value)	$\vec{A} \cdot \vec{B} = 0$ (vanished)

2 Vector (cross) product

* When multiplying the two vectors $\vec{A}$ and $\vec{B}$ (vector multiplication), the result will be vector $\vec{C}$ which is perpendicular to the plane of both vectors $\vec{A}$ and $\vec{B}$.



* The vector (cross) product of two vectors $\vec{A}$ and $\vec{B}$ is expressed as follows :

$$\vec{C} = \vec{A} \wedge \vec{B} = AB \sin \theta \, \vec{n}$$

Where : $\vec{n}$ is a unit vector perpendicular to the plane of both vectors $\vec{A}$ and $\vec{B}$, the sign (∧) is pronounced "cross" and the result $\vec{C}$ is a vector quantity its direction is determined by using **the right hand rule.**

If the angle between the two vectors $\vec{A}$ and $\vec{B}$:

$\theta = 0°$	$\theta = 90°$
Then	
$\vec{A} \wedge \vec{B} = AB \sin 0\ \vec{n}$	$\vec{A} \wedge \vec{B} = AB \sin 90\ \vec{n}$
$\vec{A} \wedge \vec{B} = 0$ (vanished)	$\vec{A} \wedge \vec{B} = AB\ \vec{n}$ (maximum value)

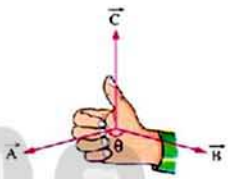
The right hand rule

Usage :

To define the direction of the vector product $\vec{C}$ of two vectors $\vec{A}$ and $\vec{B}$.

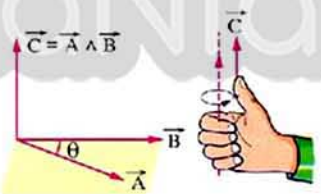
How to apply?

Move the fingers of the right hand from the first vector towards the second vector through the smaller angle between them (θ), the thumb then points to the direction of their vector product.

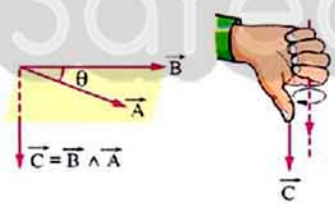


In case of :

$\vec{A} \wedge \vec{B}$



$\vec{B} \wedge \vec{A}$



Notes :

(1) $\vec{A} \cdot \vec{B} = \vec{B} \cdot \vec{A}$

(2) $\vec{A} \cdot \vec{B} = \vec{A} \wedge \vec{B}$ numerically, if $\theta = 45°$

(3) $\vec{A} \wedge \vec{B} \neq \vec{B} \wedge \vec{A}$

(4) $\vec{A} \wedge \vec{B} = -\vec{B} \wedge \vec{A}$

(5) $\vec{A} \wedge \vec{B} = 0$, if $\theta = 0$ ($\vec{A} \parallel \vec{B}$)

(6) $\vec{A} \cdot \vec{B} = 0$, if $\theta = 90°$ ($\vec{A} \perp \vec{B}$)

Example

If the magnitude of two vectors $\vec{A}$ and $\vec{B}$ are A = 5 units and B = 10 units

Find the result of each of :

(a) $\vec{A} \cdot \vec{B}$ *(b)* $\vec{A} \wedge \vec{B}$

Given that the angle between the two vectors is 60°.

Solution

(a) $\vec{A} \cdot \vec{B} = AB \cos\theta$

$= 5 \times 10 \cos 60° = 25$ units

(b) $\vec{A} \wedge \vec{B} = AB \sin\theta \, \vec{n}$

$= (5 \times 10 \times \sin 60°) \, \vec{n} = 43.3 \, \vec{n}$ units

3 Test yourself

Choose : Two vectors $\vec{x}$ and $\vec{y}$, the angle between them is 180°. Which of the following mathematical operations should equal zero ? .....

(a) $\vec{x} + \vec{y}$ (b) $\vec{x} - \vec{y}$ (c) $\vec{x} \cdot \vec{y}$ (d) $\vec{x} \wedge \vec{y}$

QUESTIONS ON

Chapter 2 Scalar and Vector Quantities

Interactive test

First Multiple choice questions

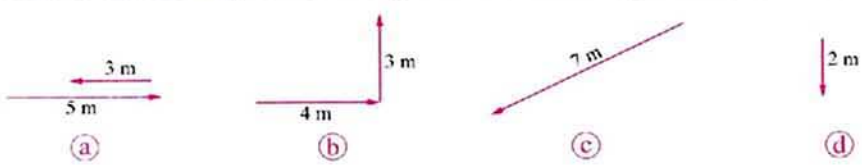
1. Which of the following sentences describes a fundamental scalar quantity ? .....
   (a) The weight of a man is 800 N
   (b) A girl moves a displacement 80 m to east
   (c) The kinetic energy of a car is 500 J
   (d) The mass of a piece of iron is 60 kg

2. From the examples of the fundamental vector quantities .....
   (a) the acting force on a body moving to east
   (b) the acceleration of a body moving to north
   (c) the mass of a static body
   (d) the displacement of a moving body

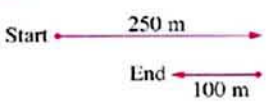
3. Which of the following sentences describes a derived vector quantity ? .....
   (a) The temperature of a body is 37°C
   (b) The displacement of a body moving to west is 50 m
   (c) The velocity by which a body moves to east is 2 m/s
   (d) The mass of a body is 10 kg

4. A rat climbs up a distance of 4 m on a wall to search for food, then returns to its starting point on the ground, so its displacement equals .....
   (a) 16 m (b) 8 m (c) 4 m (d) zero

5. In which of the following cases, the displacement has the largest value ? .....



6. An athlete covers a distance of 250 m to east then returned 100 m to west as in the opposite figure. Thus,

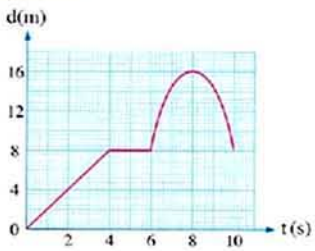


   (i) The distance he moved equals .....
   (a) 250 m (b) 350 m (c) 150 m (d) 100 m
   (ii) The displacement of the athlete is .....
   (a) 350 m to east (b) 350 m to west (c) 150 m to east (d) 150 m to west

7 In the opposite figure there is a car moving in a curved road. If the total displacement of the car is 2 km, then the distance moved by the car might be .....

(a) 3000 m (b) 2 km
(c) 1.5 km (d) 2.7 m

8 The opposite graph represents the relation between the displacement and the time for a body moving in a straight line. What is the total distance covered by the body during 10 s ? .....



(a) 0 (b) 8 m
(c) 16 m (d) 24 m

9 An object moves along the circumference of a circle of radius π, if the object covered $\frac{3}{4}$ of a revolution, then the displacement will be .....

(a) $2\sqrt{\pi}$ (b) $\sqrt{2\pi}$ (c) $\pi\sqrt{2}$ (d) $0.75\,\pi$

10 A body moves along the circumference of a circle of radius r. If it completes two revolutions, so its displacement is .....

(a) zero (b) r (c) 2r (d) $2\pi r$

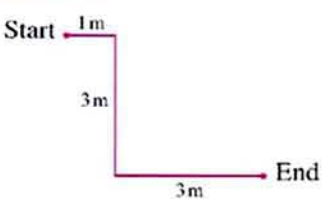
11 The magnitude of the displacement of a body moving along the circumference of a circle when it completes $\frac{1}{4}$ of a revolution is ..... the magnitude of its displacement when it completes $\frac{3}{4}$ of a revolution.

(a) half (b) 3 times (c) equal to (d) one third of

12 An object moves along the circumference of a circle of radius r. The ratio between the distance covered by it and its displacement during $\frac{1}{2}$ of a revolution is .....

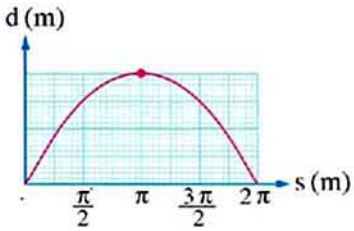
(a) π (b) 2π (c) $\frac{\pi}{2}$ (d) $\frac{\pi}{4}$

13 If a body moves as the path shown in the opposite figure, so the distance and the displacement covered by the body are ..... respectively.



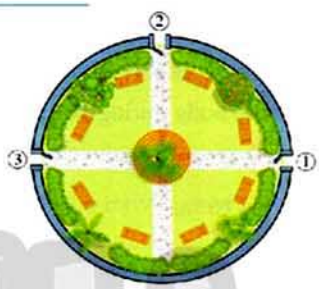
(a) 3 m , 6 m (b) 7 m , 7 m
(c) 7 m , 5 m (d) 7 m , 4 m

14 The opposite graph represents the relation between the displacement (d) and the distance (s) covered by a body which is moving in a circular path. What is the radius of this circular path ? .....



(a) 2 m (b) 1 m
(c) $\sqrt{2}$ m (d) π m

15 A body moves along the wall of the garden shown in the opposite figure which has a uniform circular shape. If the distance moved by the body from the first gate to the second gate is 44 m, then the minimum distance between the first gate and the third gate is .....



(a) 88 m (b) 44 m
(c) 56 m (d) 28 m

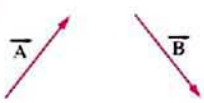
16 The vector A is usually denoted by .....

(a) $\vec{A}$ (b) A' (c) Σ A (d) $\hat{A}$

17 The two vectors $\vec{A}$ and $\vec{B}$ are equal in the figure .....

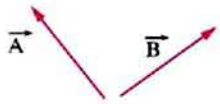
(a) (b) (c) (d)

18 The addition of the two vectors shown in the opposite diagram is represented by the diagram labeled .....



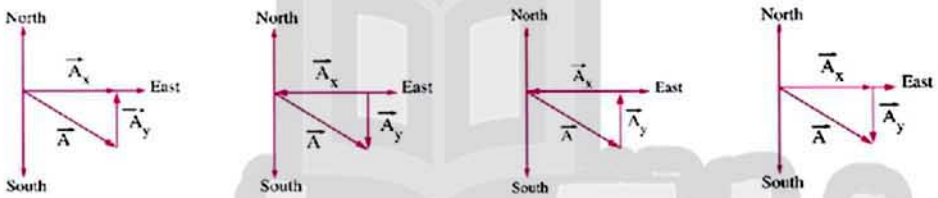
(a) (b) (c) (d)

19 The opposite figure represents two vectors $\vec{A}$ and $\vec{B}$. Which of the following figures represents the resultant of subtracting the two vectors $(\vec{B} - \vec{A})$? .....



(a) (b) (c) (d)

20 A man covered a displacement $\vec{A}$ in the eastern south direction, so the figure that describes the two components $\vec{A_x}$ and $\vec{A_y}$ for the vector $\vec{A}$ is .....



(a) (b) (c) (d)

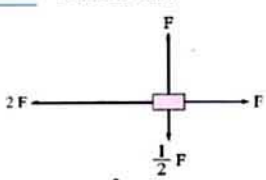
21 The ratio between the force acting on the car in the first case and the force acting on the car in the second case is .....

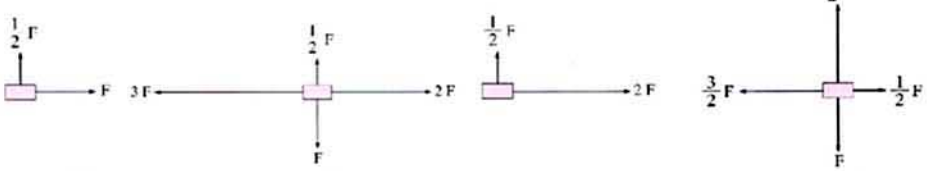
(a) greater than 1
(b) equal to 1
(c) less than 1
(d) we should know the distance moved by the car in the two cases to determine the answer.

First case

Second case

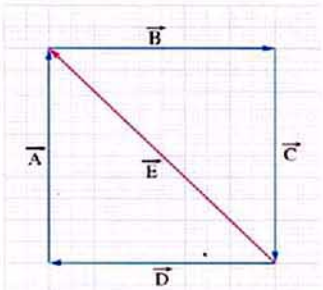
22 The opposite figure represents a body which is affected by several forces. Which one of the following figures represents a body that is affected by the same resultant force ? .....





(a) (b) (c) (d)

23 In the opposite figure there are several vectors, which one of the following relations is incorrect ? .....



(a) $\vec{B} + \vec{C} - \vec{D} - \vec{A} = -2\vec{E}$

(b) $\vec{B} + \vec{C} + \vec{D} + \vec{A} = 0$

(c) $\vec{A} + \vec{D} = \vec{E}$

(d) $-(\vec{B} + \vec{C}) = -\vec{E}$

24 A force (F) makes angle θ with the horizontal, when ..... its horizontal component (F_x) will be greater than its vertical component (F_y).

(a) $\theta < 45°$ (b) $\theta = 45°$ (c) $45° < \theta < 90°$ (d) $\theta = 90°$

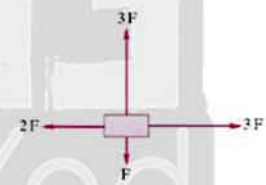
25 The opposite table shows the relation between the resultant force (F_t) of two forces and the angle (θ) between them, then the values of the two forces are ..... , ...

F_t (N)	7	5	1
θ	0	90	180

(a) 4 N , 3 N (b) 6 N , 5 N (c) 3 N , 2 N (d) 2 N , 1 N

26 In the opposite figure :

There are four forces acting on a body, where their resultant and the angle that the resultant makes with the horizontal are ..... respectively.

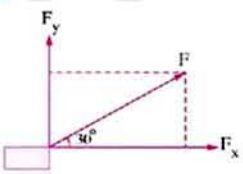


(a) $\sqrt{2}$ F , 63.43° (b) $\sqrt{5}$ F , 37.57°

(c) $\sqrt{2}$ F , 37.57° (d) $\sqrt{5}$ F , 63.43°

27 In the opposite figure :

The force F is the resultant of the two forces F_x and F_y , then .....

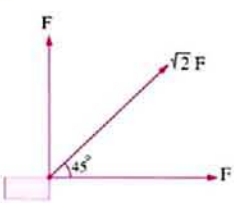


(a) $F_x < F_y < F$ (b) $F_y < F_x < F$

(c) $F < F_y < F_x$ (d) $F_y < F < F_x$

28 In the opposite figure :

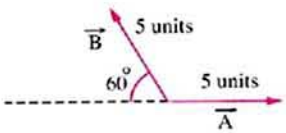
There are three forces acting on a body , where their resultant is .....

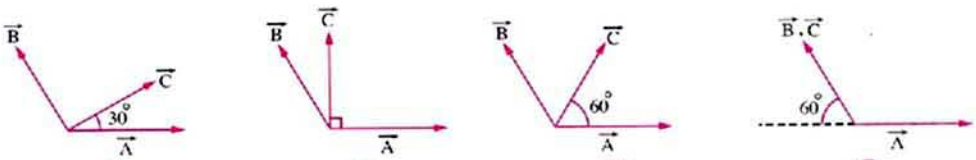


(a) 2 F (b) 3.414 F

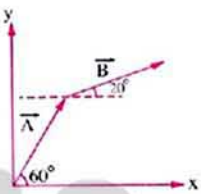
(c) $2\sqrt{2}$ F (d) $\sqrt{5}$ F

29 If the resultant of the two vectors $\vec{A}$ and $\vec{B}$ is the vector $\vec{C}$, which figure of the following figures represents the vector $\vec{C}$? .....





30 In the opposite figure the vector $\vec{A}$ has a length of 14 cm and makes an angle of 60° with the positive direction of x-axis, and the vector $\vec{B}$ has a length of 20 cm and makes an angle of 20° with the positive direction of x-axis, so the magnitude and the direction of their resultant are ..... and ..... respectively.



(a) 6 cm, makes an angle of 40° with the positive direction of x-axis
(b) 17 cm, makes an angle of 30° with the positive direction of x-axis
(c) 32 cm, makes an angle of 36° with the positive direction of x-axis
(d) 34 cm, makes an angle of 40° with the positive direction of x-axis

31 The scalar product of two vectors becomes maximum when the angle between them is .....

(a) 0° (b) 45° (c) 60° (d) 90°

32 If the magnitudes of the two vectors $\vec{A}$ and $\vec{B}$ are A = 10 units and B = 20 units and the angle between them is 60°, then the scalar product of the two vectors equals .....

(a) 200 (b) 100 (c) 70 (d) 50

33 There are two vectors $\vec{A}$ and $\vec{B}$, where A = 8 cm and B = 2 cm and the angle (θ) between them is 30°, then the magnitude of their vector product equals ..... cm.

(a) $5\sqrt{3}$ (b) 5 (c) $8\sqrt{3}$ (d) 8

34 The magnitude of the vector product of two vectors vanishes and also their resultant vanishes, when the two vectors have the same magnitude and the angle between them is .....

(a) 180° (b) 90° (c) 45° (d) 0°

35 If the angle between the two vectors $\vec{A}$ and $\vec{B}$ is θ, then $[(\vec{A} \wedge \vec{B}) + (\vec{B} \wedge \vec{A})]$ = ...

(a) AB sin θ $\vec{n}$ (b) 2 $(\vec{A} . \vec{B})$ (c) 2 $(\vec{A} \wedge \vec{B})$ (d) zero

36 The magnitudes of two perpendicular vectors are 3 units and 5 units. If the vertical vector rotates by 60°, then the vector product of the two vectors is ..... $\overline{n}$.

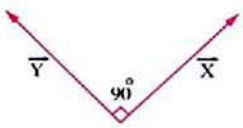
(a) 15 (b) $15\sqrt{3}$ (c) 7.5 (d) 10

37 If the angle between the two vectors $\overline{X}$ and $\overline{Y}$ is 44°, then the ratio between the magnitude of their vector product and their scalar product is .....

(a) larger than 1 (b) less than 1

(c) equal to 1 (d) there is not enough information

38 The opposite figure represents two vectors $\overrightarrow{X}$ and $\overrightarrow{Y}$ which are equal in magnitude and the angle between them equals 90°. Which one of the following operations equals zero ? .....

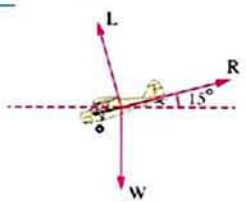


(a) $\overrightarrow{X} + \overrightarrow{Y}$ (b) $\overrightarrow{X} - \overrightarrow{Y}$ (c) $\overrightarrow{X} . \overrightarrow{Y}$ (d) $\overrightarrow{X} \wedge \overrightarrow{Y}$

39 The diagram shows two vectors $\overrightarrow{X}$ and $\overrightarrow{Y}$:

In which vector triangle does the vector $\overrightarrow{Z}$ show the magnitude and direction of vector $\overrightarrow{X} - \overrightarrow{Y}$? .....

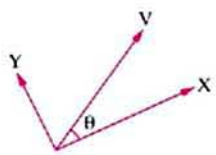
40 A glider is descending at constant speed at an angle of 15° to the horizontal. The opposite diagram shows the directions of the lift L, air resistance R and weight W acting on the glider. Which vector triangle could represent the forces acting on the glider ? .....



41 The table shows the x-component and y-component of four force vectors. Which force vector has the largest magnitude ? .....

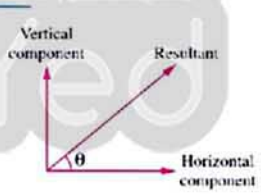
	x-component (N)	y-component (N)
(a)	2	9
(b)	3	8
(c)	4	7
(d)	5	6

42 A vector quantity $\overline{V}$ is resolved into two perpendicular components X and Y. The angle between $\overline{V}$ and the component X is θ. The angle between the component X and the vector V is increased from 0° to 90°. How do the magnitudes of X and Y change as the angle θ is increased by this way ? .....



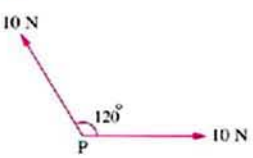
	X	Y
(a)	increase	increase
(b)	increase	decrease
(c)	decrease	increase
(d)	decrease	decrease

43 The diagram shows a resultant force and its horizontal and vertical components. The horizontal component is 20 N and θ = 30°. What is the vertical component ? .....



(a) 8.7 N (b) 10 N
(c) 11.5 N (d) 17.3 N

44 Two forces, each of 10 N, act at a point P as shown in the diagram. The angle between the directions of the forces is 120°.
What is the magnitude of the resultant force ? .....



(a) 5 N (b) 10 N
(c) 17 N (d) 20 N

45 If the vector product of two vectors $\vec{A} \wedge \vec{B} = \vec{C}$, then $\vec{A} \cdot \vec{C}$ = ...
(a) zero (b) $\vec{B}$ (c) $\vec{A}$ (d) no correct answer

UNIT 1

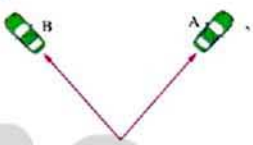
Second Essay questions

1. **Is** the distance between two objects enough to determine the location of each one of them? **And why** ?

2. **Can** you represent the distance covered by a moving body with an arrow ? **And why** ?

3. **Explain the following sentences :**
   (1) Two vectors are unequal although they have the same magnitude and a common starting point.
   (2) The magnitude of the vector product has its maximum value at $\theta = 90^\circ$

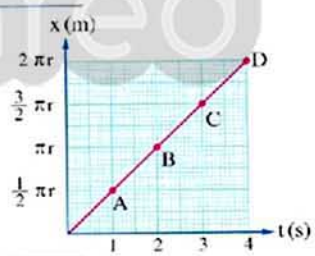
4. In the opposite figure there are two cars A and B starting their motion from the same starting point. **Explain why** their displacements aren't equal although they are equal in magnitude.



5. **When does ... ?**
   (1) The difference between two vectors equal to zero.
   (2) The magnitude of the vector product of two vectors equal to the magnitude of their dot product ?

6. **What happens when** three forces of different magnitudes and directions act on a stationary object ?

7. The opposite figure shows the (distance - time) graph of a body moving in a circular path of radius r :
   (a) **At what point** does the displacement equal 2r ?
   (b) **What** is the displacement of the body when it reaches point D ?

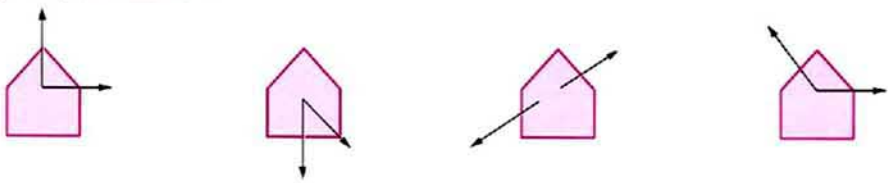


8. **Is** it possible for the magnitude of a vector to be a negative value ? **Explain.**

9. **Illustrate by drawing only the resultant of forces indicated in each diagram :**

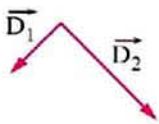
(1) (2)

10 Two vectors of magnitude 4 cm and 3 cm respectively, **arrange** the following cases of the two vectors according to the magnitude of the resultant in each case. **And then explain your answer.**



(1) (2) (3) (4)

11 The opposite figure shows the two vectors $\overrightarrow{D_1}$ and $\overrightarrow{D_2}$. **Which** one of the following vectors represent the vector $(\overrightarrow{D_2} - 2\overrightarrow{D_1})$? **Explain your answer.**



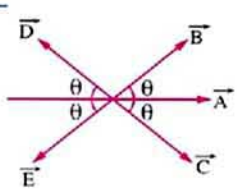
(1) (2) (3) (4)

12 If $\vec{F} = \vec{V} \wedge \vec{B}$ and the vector $\vec{V}$ is perpendicular on the vector $\vec{B}$, **what** is the direction of vector $\vec{F}$ in the following two cases ?

(1) (2)

13 If $\vec{a} \cdot \vec{b} = \vec{a} \cdot \vec{c}$, **do** $\vec{b}$ and $\vec{c}$ must be equal ? **And why** ?

14 The opposite figure shows four vectors $\vec{B}$, $\vec{C}$, $\vec{D}$ and $\vec{E}$ that are equal in magnitude and opposite in direction.
If each vector of them was multiplicated by the vector $\vec{A}$ a scalar multiplication, **then which of the scalar products of the previous operation :**



(a) are equal.

(b) have a negative value.

UNIT 1

15 **Which of the following mathematical expressions is right and which of them is wrong ? Explaining the wrong expressions.**

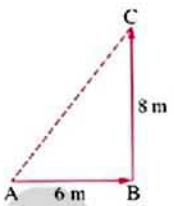
(1) $\vec{A} \cdot (\vec{B} \cdot \vec{C})$ (2) $\vec{A} \wedge (\vec{B} \cdot \vec{C})$

(3) $\vec{A} \cdot (\vec{B} \wedge \vec{C})$ (4) $\vec{A} \wedge (\vec{B} \wedge \vec{C})$

Third Problems

Distance and displacement :

1 An object has moved from the position (A) to the position (B) then it changed its direction to reach position (C) as shown in the figure. **Find :**



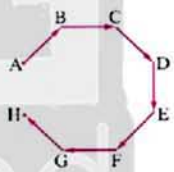
(a) The covered distance.

(b) The object displacement.

(c) The distance and displacement when it returns to position (A).

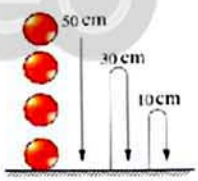
(14 m, 10 m in the direction of $\overrightarrow{AC}$, 28 m, zero)

2 **Use the opposite diagram to find** the displacement and the distance moved from A to H given that the length of each side = 10 m



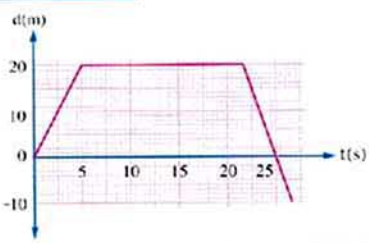
(10 m in direction of $\overrightarrow{AH}$, 70 m)

3 A rubber ball fell from 50 cm high and kept bouncing along a vertical path as shown in the opposite figure. **Find** the total distance and the total displacement covered by it.



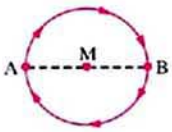
(130 cm, 50 cm downwards)

4 The opposite graph represents the relation between the displacement of an object and time. **Find** its displacement and the total distance covered by it.



(– 10 m, 50 m)

5 **Find** the distance and displacement of an object when it moves along the circumference of a circle of center M and a radius of 7 m from A to B, **then find** the distance and displacement when it returns back to A one more time.



(22 m, 14 m in the direction of $\overrightarrow{AB}$, 44 m, zero)

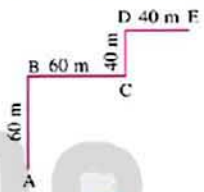
6 An object moves along the circumference of a circle of diameter 4 m. **Find** the distance and the displacement covered by the object when it :

(a) covers half the circle.

(b) completes one revolution.

(c) makes 1.75 revolutions. (6.28 m, 4 m, 12.57 m, 0 , 22 m, $2\sqrt{2}$ m)

7 In the opposite diagram, a person has moved from point (A) to point (E) passing by the points (B), (C) and (D). **Find** his displacement and the distance moved by him.



($100\sqrt{2}$ m in the direction of $\overrightarrow{AE}$, 200 m)

8 A boy rides his bicycle starting from point A and moves a distance of 4.55 km to the east , then he takes a circular path which its center is the point A and he moves in clockwise direction till he reaches the point B which is located directly south the point A, after that he moves a distance 1.8 km to north till he reaches the point C. **calculate :**

(a) The displacement of the boy from the point A.

(b) The total distance moved by the boy. (2.75 km in the direction of $\overrightarrow{AC}$, 13.5 km)

Vectors :

9 **Use the ruler and the protractor to find** the resultant of two vectors that start from the same point and the magnitude of the first (2 cm) while the other (3 cm) and the angle between their directions (115°).

10 **Find** the magnitude and the direction of the resultant of two perpendicular forces $\overrightarrow{F_x}$, $\overrightarrow{F_y}$, knowing that they have the same starting point where $F_x = 8$ N , $F_y = 6$ N
Show that by drawing the vectors. (10 N , 36.87°)

11 Two equal perpendicular forces $F_1 = F_2$ act on an object. If their resultant has magnitude of 20 N and makes an angle 45° with the x-axis, **find :**

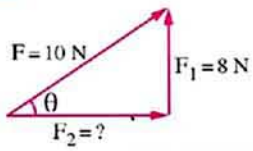
(a) The magnitude of each of F_1 and F_2

(b) The dot product and the cross product of the two forces.

(14.14 N, 14.14 N, 0, 199.9 $\vec{n}$)

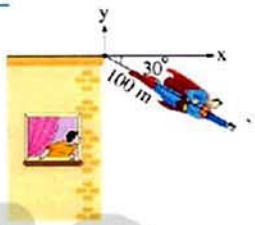
12 Two forces act on the same body, one of them $(\overrightarrow{F_1})$ is in the direction of north and its magnitude is 9 N and the other $(\overrightarrow{F_2})$ is in the direction of west and its magnitude is 12 N.
Calculate the resultant of the two forces F. (15 N)

13 The resultant of two perpendicular forces is 10 N as in the opposite figure and the magnitude of one of them is 8 N. **Find** the magnitude of the other one and the angle it makes with the resultant.



(6 N, 53.13°)

14 **Calculate** the horizontal and the vertical components of the displacement covered by Superman in the opposite figure.



(50√3 m , 50 m)

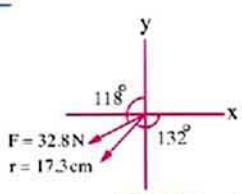
15 A ship sails to north at velocity 12 km/h. Due to tide, it is deviated to west at velocity 15 km/h. **Find** the magnitude and direction of the resultant velocity of the ship.
(19.2 km/h, 38.66° in the northern west direction)

16 A motorcyclist drove to north at velocity 80 km/h. Meanwhile wind was blowing towards west at velocity 50 km/h. **Calculate** the apparent velocity of wind as observed by the motorcyclist. (94.34 km/h to the western south)

17 A small aircraft had departed the airport. After a while, the pilot reported the airport tower that the craft is at 215 km away in a northern east direction that makes an angle 22° to east. **How far** was the craft from the tower to the east and to the north?
(199.34 km, 80.54 km)

18 Two forces $F_1 = 4$ N , $F_2 = 9$ N act on a static body, **calculate** the resultant magnitude and direction if :
(a) The two forces are in opposite direction and act on the same line of action.
(b) F_1 is in x-direction, F_2 makes an angle 100° with the x-axis.
(5 N in the direction of F_2 , 9.19 N , 74.6°)

19 **Find** the dot product of the two vectors shown in the figure.



(533.2 N.cm)

20 Vector $\vec{a}$ has a horizontal component of 3 units and a vertical component of 5 units and vector $\vec{b}$ has a horizontal component of 2 units and a vertical component of 4 units.

Calculate :

(a) $\vec{a} \wedge \vec{b}$ (b) $\vec{a} \cdot \vec{b}$ (c) $(\vec{a} + \vec{b}) \cdot \vec{b}$

($2\vec{n}$ units, 26 units, 46 units)

---

21 Two vectors (A = 3 units , B = 5 units) have scalar product of 7.5, **calculate** their vector product and then mention the used rule to define the direction of the vector product of the two vectors A and B. ($12.99\vec{n}$, the right hand rule)

---

22 There are two vectors $\vec{A}$ and $\vec{B}$, where the magnitude of vector $\vec{A}$ is double the magnitude of vector $\vec{B}$ and their vector product equals $13.5\vec{n}$ and their scalar product equals $4.5\sqrt{3}$. **Calculate** the magnitude of vector $\vec{A}$. (5.58 units)

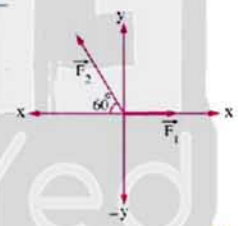
---

23 **Use the opposite diagram to find** the dot product and the cross product of the two forces $\overrightarrow{F_1}$ and $\overrightarrow{F_2}$

(– 7200 N, zero)

---

24 In the opposite diagram two forces $\overrightarrow{F_1}$ of magnitude 6 N and $\overrightarrow{F_2}$ of magnitude 9 N act at a certain point. **Find** the dot product and the cross product of the two forces.



(– 27 N , $46.77\vec{n}$)

---

25 The following table illustrates the relation between the displacement of a body in straight line and time :

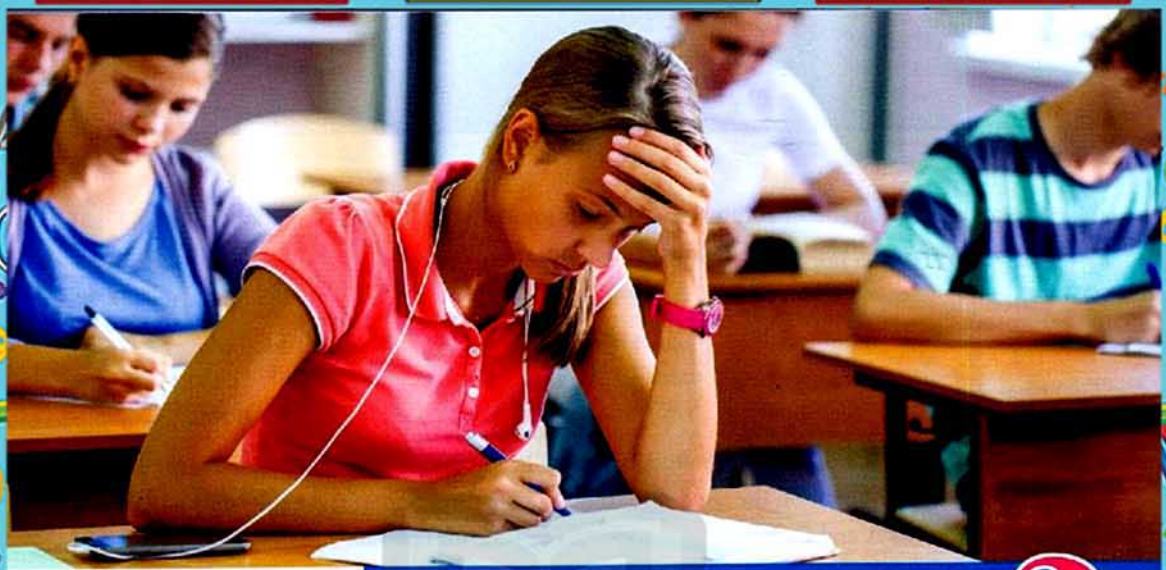
d (m)	0	5	10	15	10	10
t (s)	0	1	2	3	4	5

(a) **Plot the graph between** displacement (d) on y-axis and time (t) on x-axis.

(b) **From the graph find :**

1- The displacement. 2- The total distance covered by the body.

(10 m, 20 m)



MODEL EXAM ON

Chapter 2

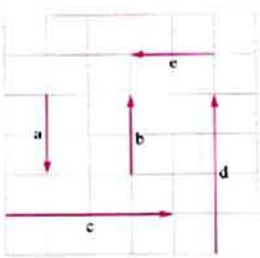
Scalar and Vector Quantities

First Choose the correct answer

1. The vector product of the two vectors $\vec{A}$ and $\vec{B}$ in figure (1) is .....
   - (a) greater than that in figure (2)
   - (b) less than that in figure (2)
   - (c) equal to the vector product of the two vectors $\vec{A}$ and $\vec{B}$ in figure (2)
   - (d) equal to the scalar product of the two vectors $\vec{A}$ and $\vec{B}$ in figure (2)

Figure (1) Figure (2)

2. The following figure represents a group of vectors, then vector $\vec{c}$ equals .....
   - (a) $1.5\,\vec{b}$
   - (b) $-2\,\vec{e}$
   - (c) $-\vec{d}$
   - (d) $2\,\vec{a}$

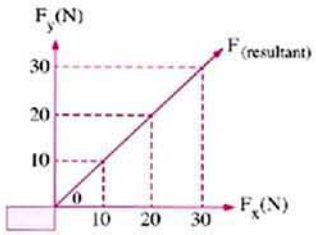


3. If the distance covered by a body moving in a circular path after $\frac{1}{8}$ revolution is 22 m, then its displacement during $\frac{1}{4}$ revolution equals .....
   - (a) 28 m
   - (b) 44 m
   - (c) $14\sqrt{2}$ m
   - (d) $28\sqrt{2}$ m

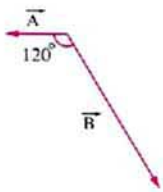
4 In the opposite figure there are two perpendicular forces F_x and F_y, so the value of angle θ is .....

(a) 30° (b) 60°

(c) 45° (d) 90°



5 The opposite figure shows two vectors $\overline{A}$ and $\overline{B}$ which have magnitudes of 50 units and 150 units respectively. The magnitude and the direction of their vector product ($\overline{A} \wedge \overline{B}$) are ..... and ..... respectively.



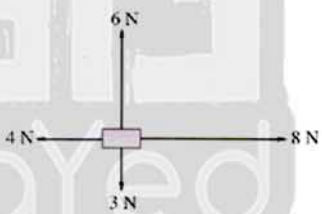
(a) 6495.19 units, perpendicular on the page inwards

(b) 3750 units, perpendicular on the page outwards

(c) 3750 units, perpendicular on the page inwards

(d) 6495.19 units, perpendicular on the page outwards

6 The opposite figure shows four forces acting on a body, so the magnitude and the direction of their resultant are ..... and ..... respectively.



(a) 8 N, makes angle 53.13° with the horizontal

(b) 8 N, makes angle 45° with the horizontal

(c) 5 N, makes angle 36.87° with the horizontal

(d) 5 N, makes angle 30° with the horizontal

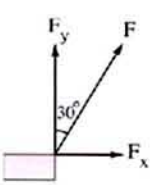
7 If the Earth orbits the Sun in a circular path of radius 1.5×10^{11} m and it completes one revolution every solar year, then the displacement of the Earth during three months is ..... (neglecting the motion of the Sun)

(a) $\sqrt{2} \times 10^{11}$ m (b) 3×10^{11} m (c) $2\sqrt{2} \times 10^{11}$ m (d) 2.12×10^{11} m

8 In the opposite figure the force F is the resultant of the two forces F_x and F_y, then .....

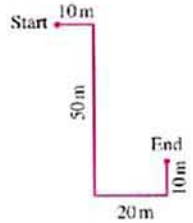
(a) $F_x < F_y < F$ (b) $F_y < F_x < F$

(c) $F < F_y < F_x$ (d) $F_y < F < F_x$



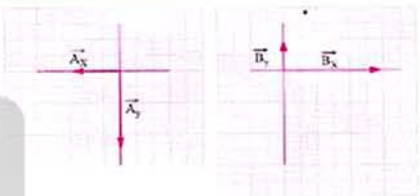
UNIT 1

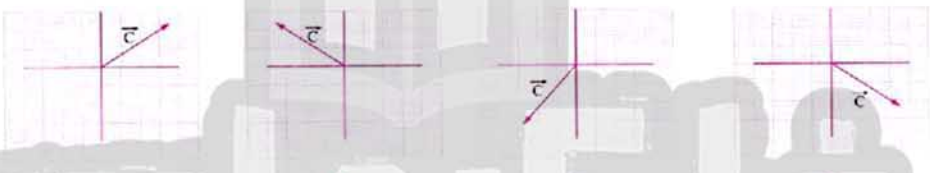
9 If a body moves in the shown path, then the displacement and the distance covered by it are ..... and ..... respectively.



(a) 100 m , 50 m
(b) 90 m , 20 m
(c) 90 m , 90 m
(d) 50 m , 90 m

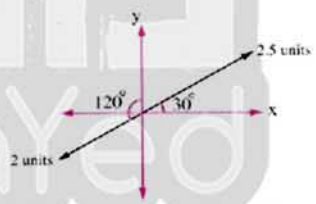
10 The opposite figures represents the components of the vectors $\overrightarrow{A}$ and $\overrightarrow{B}$, so which of the following figures represent the resultant of the two vectors ? .....





Second Answer the following questions

11 **Find** the scalar product of the two vectors shown in the opposite figure.



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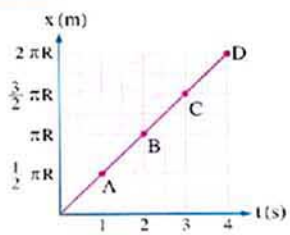
12 The opposite figure represents the (distance - time) graph of a body moving in a circular path of radius R. **What** is the ratio between its displacement at point A and its displacement at point B.



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13 **When does** $\vec{X} \cdot \vec{Y} = \vec{X} \cdot \vec{Z}$ **?**

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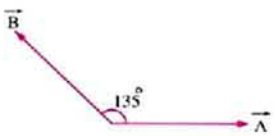
14 The opposite figure shows two vectors $\vec{A}$ and $\vec{B}$, where A = 8 cm and the resultant of the two vectors is perpendicular on $\vec{A}$. **Calculate** the magnitude of vector $\vec{B}$.



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15 **Which of the following mathematical expressions is right ? Explaining the wrong expressions :**

(1) $(\vec{A} + \vec{B}) + (\vec{B} \cdot \vec{C})$

(2) $(\vec{A} \cdot \vec{B}) + (\vec{B} \wedge \vec{C})$

.....

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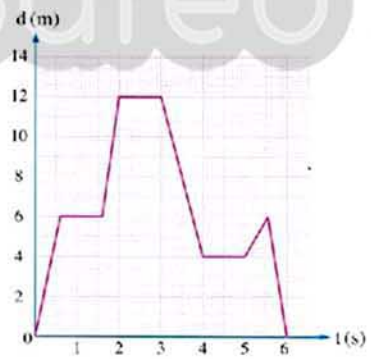
16 The opposite (displacement - time) graph describes the motion of a man moving in a track. If he starts his motion from one end of the track, **calculate :**

(a) The minimum length of the track.

(b) The distance and the displacement covered by the man.



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17 Vector $\vec{A}$ has a horizontal component of 4 cm and a vertical component of – 7.5 cm. Vector $\vec{B}$ has a horizontal component of – 2.5 cm and a vertical component of 5 cm. If $\vec{A} + \vec{C} = \vec{A} + \vec{B}$, **find** the components of vector $\vec{C}$.

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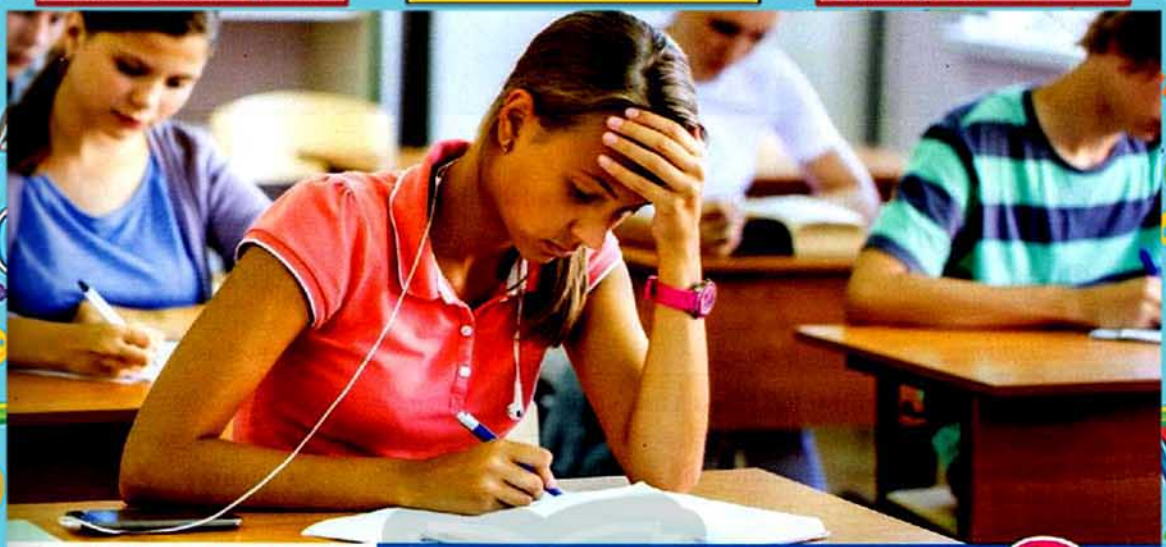


ACCUMULATIVE EXAM

ON UNIT 1

Physical Quantities and Measuring Units

First Choose the correct answer

1. The pound is the measuring unit of the mass in the ..... system.
   (a) British (b) international
   (c) French (d) all answers are correct

2. The best way to judge the accuracy of measurement is through .....
   (a) the absolute error
   (b) the relative error
   (c) the product of the relative error and the absolute error
   (d) all of them

3. Based on the right hand rule for the cross product of two vectors. The thumb points to the direction of .....
   (a) the first vector
   (b) the second vector
   (c) the first vector with respect to the second
   (d) vector product of the two vectors

4. If the kinetic energy of a body is given by the relation $\frac{1}{2}$ mv^2, then its dimensional formula is .....
   (a) ML^2T^2 (b) MLT^{-2} (c) $ML^{-1}T^{-2}$ (d) ML^2T^{-2}

5. The vernier caliper is used in measuring .....
   (a) small masses (b) the distance between cities
   (c) small lengths (d) large intervals of time

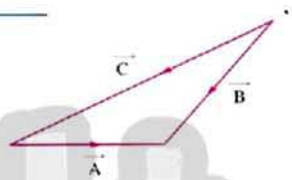
UNIT 1

6 For the resultant of two vectors to be maximum, the angle between them must be .....
(a) 0° (b) 60° (c) 90° (d) 180°

7 If two forces $\overrightarrow{F_1}$ = 4 N and $\overrightarrow{F_2}$ = 3 N acted on a body, then the net force on the body is .....
(a) 7 N (b) 5 N (c) 1 N (d) between 1 N and 7 N

8 If the resultant of two forces has a magnitude smaller than that of the larger force , then the two forces must be .....
(a) different in both magnitude and direction
(b) perpendicular to each other
(c) having very small magnitudes
(d) in opposite direction

9 Which of the following choices describes the opposite figure ? .....



(a) $\overrightarrow{A} + \overrightarrow{B} = \overrightarrow{C}$ (b) $\overrightarrow{B} + \overrightarrow{C} = \overrightarrow{A}$
(c) $\overrightarrow{C} + \overrightarrow{A} = \overrightarrow{B}$ (d) $\overrightarrow{A} + \overrightarrow{B} + \overrightarrow{C} = 0$

10 Hassan measured the length of a building by a meter tape, it was found to be (10 ± 0.1) m, then .....

	The type of measurement	The absolute error	The relative error
(a)	Direct	10 m	0.01
(b)	Direct	0.1 m	0.01
(c)	Indirect	10 m	0.001
(d)	Indirect	0.1 m	10.1

Second Answer the following questions

11 **Mention** one use for the hydrometer.
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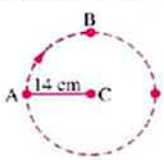
12 **From the opposite figure :**
If a body moves along the circumference of the circle from point A to point B, **calculate** the covered distance and displacement by the body.



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13 If : $x = (5 \pm 0.1)$ m and $y = (7 \pm 0.2)$ m, **calculate :**

(a) $\frac{x}{y}$ (b) $x + 2y$

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14 Cylinder of radius 5 cm and height 20 cm, is made of iron of density 7800 kg/m^3, **find :**

(a) The volume of the cylinder in nm^3.

(b) The mass of the cylinder in mg.

.....

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15 An aeroplane had departed the airport. After a while, the pilot reported the airport tower that the craft is at 325 km away in a northern west direction that makes an angle 35° to west. **How far** was the aeroplane from the tower to the west and to the north ?

.....

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16 Two equal perpendicular forces $F_1 = F_2$ act on an object. If their resultant has a magnitude of 35 N and makes an angle 45° to y-axis, **find :**

(a) The magnitude of each F_1 and F_2.

(b) The dot product and the cross product of the two forces.

.....

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17 **Calculate** the absolute error in measuring the area of a room, if the relative error in measuring it is 0.04 and the actual area is 45 m^2.

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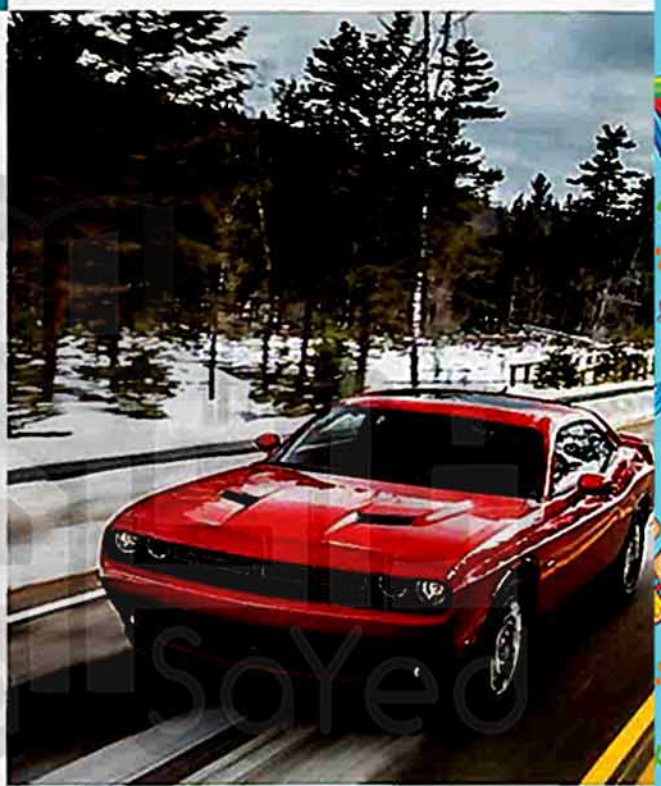
UNIT 2

Linear Motion



Unit objectives

By the end of this unit, the student will be able to :

Chapter 1 :

- Define the concept of motion in a straight line.
- Identify the types of motion.
- Plot and explain the different graphs that represent the relationships : (displacement – time) and (velocity – time).
- Differentiate and compare the types of velocity.
- Inquire, analyze and explain the graphical representations related to linear motion.

Chapter 2 :

- Deduce the equations of motion at uniform acceleration.
- Identify the motion of objects under free fall.
- Conclude the motion in two dimensions such as projectile motion.
- Design an experiment to determine the free fall acceleration.

Chapter 3 :

- Define the concept of force and inertia.
- Explain the action – reaction coupling.

Chapter 1

Motion in a Straight Line.

Lesson 1 : Motion.

Lesson 2 : Acceleration.

▶ **Model Exam on Chapter 1.**

Chapter 2

Motion with Uniform Acceleration.

Lesson 1 : Equations of Motion.

Lesson 2 : Applications of Motion with Uniform Acceleration (Free Fall – Vertical Projectiles).

Lesson 3 : Follow Applications of Motion with Uniform Acceleration (Two-Dimensional Projectiles).

▶ **Model Exam on Chapter 2.**

Chapter 3

Force and Motion.

▶ **Model Exam on Chapter 3.**

▶ **Accumulative Exam on Units (1 & 2).**

Chapter 1

LESSON ONE

Motion

Motion :

- **The concept of motion** is related to the change in the position of an object relative to another static object as time passes, then when the position of an object changes as time passes we can say that the object is moving.

Static object

- The motion of an object can be represented by : taking a series of successive photos in equal intervals of time and by putting these photos in one photo we get a pattern that shows the sequence of motion which is called **the motion diagram.**

Enrichment information

For simplicity, any body is treated as a point, neglecting by that the internal structure, the volume and the geometrical shape of the body even if this body is a person or a galaxy.

Types of Motion :

- **Motion can be classified into two main types :**

1 Translational motion	2 Periodic motion
It is the motion which is characterized by having a starting point and an end point.	It is the motion that repeats itself over equal intervals of time.

UNIT 2

Examples

Motion in a straight line (the simplest type of motion) :

For example :

- The train motion.
- The motion of a ball sliding on a horizontal plane.

Projectile motion :

For example : The motion of a projectile which is projected from the nozzle of a cannon.

Vibrational motion :

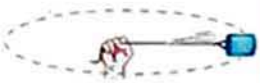
For example :

- The pendulum motion.
- The motion of the strings of the musical instruments.

Circular motion :

For example :

- The motion of a mass which is tied to a thread and moving in a circular path.

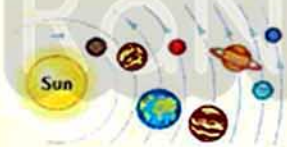


- The motion of the Moon around the Earth during a month.

1 Test yourself

Determine the type of motion of each of the following bodies :

1. The motion of the planets around the Sun.



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2. The motion of a box which is sliding on an inclined plane.

.....

3. The motion of electrons around the nucleus.

.....

4. The motion of a mass which is attached to a spring.

.....

5. The motion of a bullet which is fired from the nozzle of a pistol.

.....

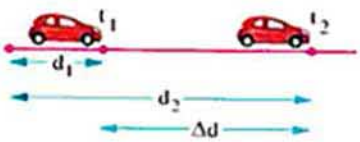
6. The motion of the blades of a fan.

.....

Now we will study some concepts which is related to the motion in a straight line such as velocity and acceleration.

Velocity (v)

- If a car moves to cover a distance in a certain direction (displacement) Δd in time interval Δt, the car velocity (v) can be found by the relation :



$$v = \frac{\Delta d}{\Delta t} = \frac{d_2 - d_1}{t_2 - t_1}$$

- The unit of measuring velocity is **m/s** or **km/h** and its dimensional formula is $L\,T^{-1}$.

⊙ The difference between the speed and the velocity of a body :

① Speed	② Velocity
The distance moved by the object per unit of time.	The displacement of the object per unit of time.
Scalar quantity; defined by its magnitude only.	Vector quantity; defined by its magnitude and direction.
Always positive.	Positive in a certain direction and negative in the opposite direction.

Example

Assume that :
The east direction is the positive direction.

Then

- The two cars (a) and (b) move with a speed of 80 km/h.
- The car (a) moves with velocity + 80 km/h in the east direction.
- The car (b) moves with velocity – 80 km/h in the west direction.

UNIT 2

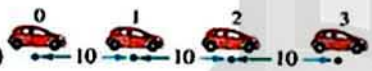
Types of velocity :

1 Uniform velocity

The velocity by which the object moves through **equal displacements** in equal intervals of time, where the object moves at a velocity of constant magnitude in one direction (straight line).

Example

A car is moving as shown in figure according to the data given in the table below :



d (m)	0	10	20	30	40	50
t (s)	0	1	2	3	4	5

From the previous table, the velocity can be determined from the relation : $v = \frac{\Delta d}{\Delta t}$

$$v_1 = \frac{\Delta d_1}{\Delta t_1} = \frac{10-0}{1-0} = 10 \text{ m/s}$$

$$v_2 = \frac{\Delta d_2}{\Delta t_2} = \frac{20-10}{2-1} = 10 \text{ m/s}$$

$$v_3 = \frac{30-20}{3-2} = 10 \text{ m/s}$$

$$v_4 = \frac{40-30}{4-3} = 10 \text{ m/s}$$

$$v_5 = \frac{50-40}{5-4} = 10 \text{ m/s}$$

Obviously, we find that the car is displaced through equal displacements in equal intervals of time. So, it is called **uniform velocity**.

Notice that

The velocity has a constant magnitude.

2 Non-uniform velocity

The velocity by which the object moves through **unequal displacements** in equal intervals of time, where the velocity changes its magnitude or direction or both of them.

Example

A car is moving as shown in figure according to the data given in the table below :

d (m)	0	2	6	12	20	30
t (s)	0	1	2	3	4	5

From the previous table, the velocity can be determined from the relation : $v = \frac{\Delta d}{\Delta t}$

$$v_1 = \frac{\Delta d_1}{\Delta t_1} = \frac{2-0}{1-0} = 2 \text{ m/s}$$

$$v_2 = \frac{\Delta d_2}{\Delta t_2} = \frac{6-2}{2-1} = 4 \text{ m/s}$$

$$v_3 = \frac{12-6}{3-2} = 6 \text{ m/s}$$

$$v_4 = \frac{20-12}{4-3} = 8 \text{ m/s}$$

$$v_5 = \frac{30-20}{5-4} = 10 \text{ m/s}$$

Obviously, we find that the car is displaced through unequal displacements in equal intervals of time. So, it is called **non-uniform velocity**.

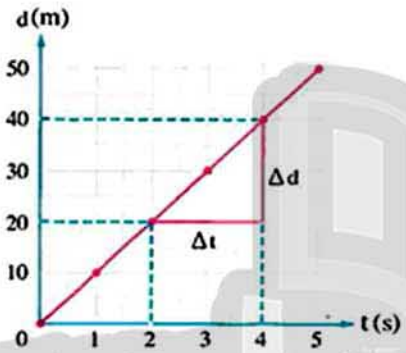
Notice that

The velocity has a variable magnitude.

Graphical representation

When plotting the relation between the displacement (d) on the ordinate (y-axis) and time (t) on the abscissa (x-axis), we may get :

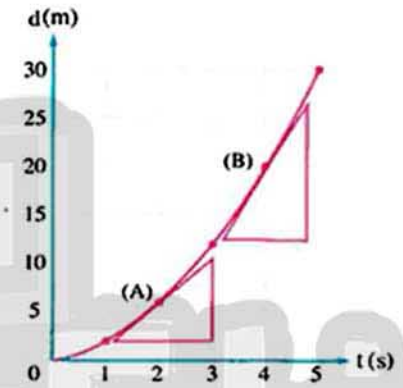
A straight line



The slope of the straight line gives the uniform velocity at which the object moves :

$$\text{Slope} = v = \frac{\Delta d}{\Delta t} = \frac{40 - 20}{4 - 2} = 10 \text{ m/s}$$

A curve



The slope of the tangent drawn to the curve at any point gives the instantaneous velocity of the object at this point :

- The velocity of the car at t = 2 s

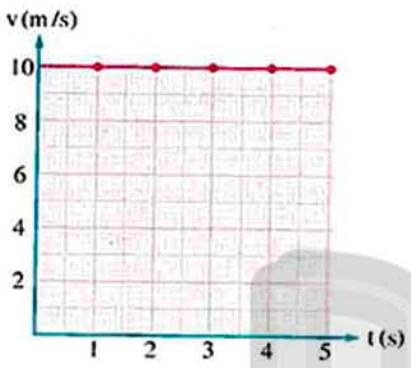
$$\text{Slope at (A)} = v_A = \frac{\Delta d_1}{\Delta t_1} = \frac{10.5 - 2}{3 - 1.1} = 4.5 \text{ m/s}$$

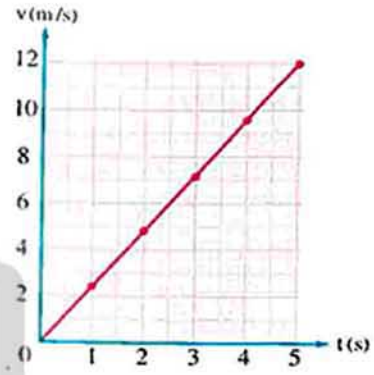
- The velocity of the car at t = 4 s

$$\text{Slope at (B)} = v_B = \frac{\Delta d_2}{\Delta t_2} = \frac{26.5 - 12.5}{4.8 - 3.2} = 8.8 \text{ m/s}$$

UNIT 2

When plotting the relation between the velocity (v) on the vertical axis and the time (t) on the horizontal axis, we may get :





This means that :

- The car covered equal displacements in equal intervals of time, so the car is moving with **a uniform (constant) velocity** of magnitude 10 m/s.
- The car covered unequal displacements in equal intervals of time, so the car is moving with **non-uniform velocity.**

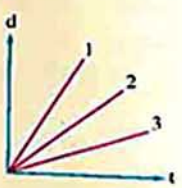
2 Test yourself

1 **Choose :** The opposite figure shows a man that stands on the platform of a train station, where he observes a train that moves with a velocity of 30 m/s. If the train takes 3 s to pass till its end in front of the man, so the length of the train is .....

(a) 10 m (b) 27 m (c) 30 m (d) 90 m

2 The opposite graph describes the motion of three bodies, **arrange** these bodies according to their velocities.

.....



⊙ When the object moves at a uniform or non-uniform velocity :

1. The velocity of the object at a certain instant is called **the instantaneous velocity (v)**.
2. The average of the body's velocity during a certain interval of time is called **the average velocity ($\bar{v}$)**.

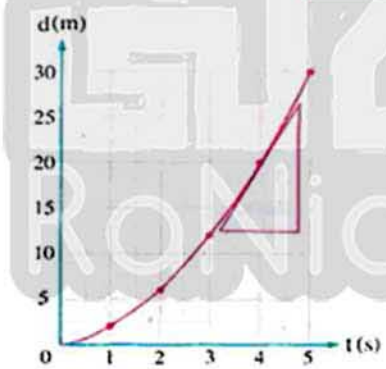
① Instantaneous velocity (v)	② Average velocity ($\bar{v}$)
The velocity of the object at a given instant.	The total displacement of the object from the starting point to the end point divided by the total time of motion.

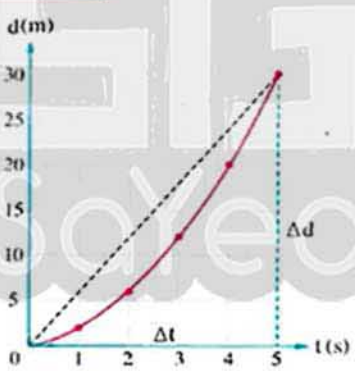
The mathematical relation

It is determined from the slope of the tangent of the (displacement - time) curve at a certain instant.

$$(\bar{v}) = \frac{\text{d (Total displacement)}}{\text{t (Total time)}}$$

Graphical representation





The instantaneous velocity of an object is given by the slope of the tangent drawn to the curve at the point corresponding to that instant.

$$\text{Slope of tangent} = v = \frac{\Delta d}{\Delta t} = \frac{26.5 - 12.5}{4.8 - 3.2}$$
$$= 8.8 \text{ m/s}$$

Which means that : the instantaneous velocity at time 4 s is 8.8 m/s.

The average velocity of an object is given by the slope of the line joining the starting point and the end point.

$$\text{Slope of line} = \bar{v} = \frac{\Delta d}{\Delta t} = \frac{30 - 0}{5 - 0}$$
$$= 6 \text{ m/s}$$

Which means that : the average velocity of the object is 6 m/s.

UNIT 2

Notes :

1. The average velocity differs from the average speed where :

$$\text{Average velocity} = \frac{\text{Total displacement}}{\text{Total time}}$$

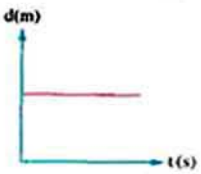
Average velocity is a **vector quantity**.

$$\text{Average speed} = \frac{\text{Total distance}}{\text{Total time}}$$

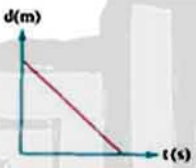
Average speed is a **scalar quantity**.

2. Instantaneous velocity equals average velocity when the object moves by a uniform velocity in a straight line.

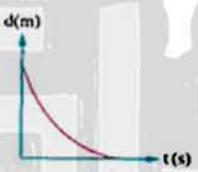
3. A body at rest is represented graphically in the displacement (d) - time (t) graph by a straight line parallel to the time axis (slope = 0).



4. If the object was moving towards a fixed point, then the graphical relation between the displacement of the object from this point (d) and time (t) becomes :



if



The object is moving with a uniform velocity.

The object is moving with a non-uniform velocity.

5. The displacement covered by a body can be determined from the (velocity - time) graph that describes the motion of the body, where :
The displacement = The area under the (velocity - time) curve

Example 1

A person drove a car in a straight line to cover 8.4 km in 0.12 h. When the fuel had run out, he walked 2 km along the same straight line to reach the nearest gas station after 0.5 h.

(a) Calculate the average velocity of the person during this journey.

(b) If the person returned back to his car in 0.6 h, calculate his average velocity during the whole journey.

Solution

(a)

Average velocity $(\bar{v}) = \frac{\text{Total displacement (d)}}{\text{Total time (t)}}$

$\bar{v} = \frac{d}{t} = \frac{8.4 + 2}{0.12 + 0.5} = 16.77$ km/h

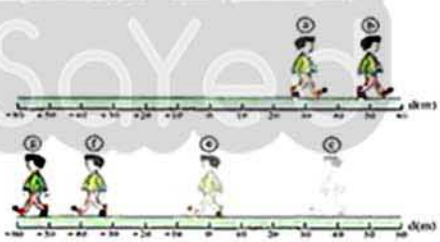
(b)

When the person returns back to the car, his total displacement = 8.4 km

$\bar{v} = \frac{d}{t} = \frac{8.4}{0.12 + 0.5 + 0.6} = 6.89$ km/h

Example 2

The opposite figure shows a man that moves from point a to point b, then he returns back until he reaches point g passing by points c, e and f.



The opposite table shows the position of the man at each point and the time taken to reach that point :

Calculate :

(a) The total displacement of the man.

(b) The average velocity.

(c) The average speed.

	t (s)	d (m)
a	0	30
b	10	52
c	20	38
e	30	0
f	40	– 37
g	50	– 53

Solution

(a)

Clue

The man starts his motion from point a (+ 30 m) and ends his motion at point g (– 53 m), which means that his displacement is in the negative direction.

$$\Delta d = d_g - d_a$$
$$= -53 - 30$$
$$= -83 \text{ m}$$

(b) $v = \frac{\Delta d}{\Delta t} = \frac{-83}{50 - 0} = -1.66$ m/s

(c)

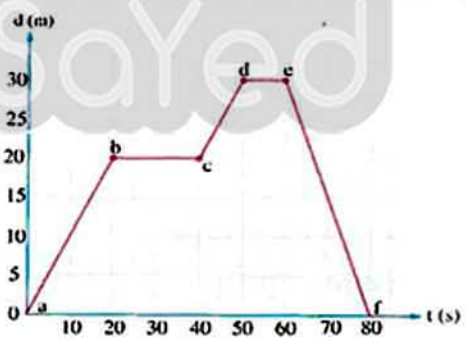
Clue

The man moves from point a to point b to cover distance s_{ab}, then he returns from point b to point g to cover distance s_{bg}

$$s_t = s_{ab} + s_{bg}$$
$$= (52 - 30) + (52 - (-53)) = 127 \text{ m}$$
$$\therefore v = \frac{\text{Total distance}}{\text{Total time}} = \frac{127}{50 - 0} = 2.54 \text{ m/s}$$

Example 3

The next graph represents the motion of a girl from her home until she returns back. Study the diagram, then find :



(a) The time intervals at which the girl has stopped.

(b) The maximum velocity at which the girl has moved.

(c) Why is the velocity negative when returning back?

(d) The displacement and total distance covered by the girl.

(e) The average velocity and the average speed of the girl.

Solution

(a)

Clue

The time intervals at which the girl has stopped are the intervals at which the displacement of the girl doesn't change with time.

The girl has stopped at the intervals : bc and de

(b)

Clue

The velocity of the girl is determined from the slope of the straight line that represents the (displacement - time) relation.

$$v_{ab} = \frac{20 - 0}{20 - 0} = \frac{20}{20} = 1 \text{ m/s}$$

$$v_{bc} = 0$$

$$v_{cd} = \frac{30 - 20}{50 - 40} = \frac{10}{10} = 1 \text{ m/s}$$

$$v_{de} = 0$$

$$v_{ef} = \frac{0 - 30}{80 - 60} = \frac{-30}{20} = -1.5 \text{ m/s}$$

The maximum velocity at which the girl has moved = 1.5 m/s

(c) The velocity is negative when returning back because the girl moved in the opposite direction.

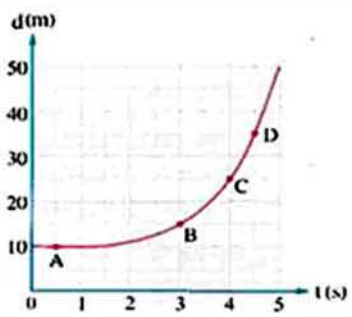
(d) d = 0 , s = 20 + 10 + 30 = 60 m

(e) The average velocity = $\frac{\text{Total displacement}}{\text{Total time}}$ = zero

The average speed = $\frac{\text{Total distance}}{\text{Total time}} = \frac{60}{80}$ = 0.75 m/s

Example 4

The opposite graph shows the relation between the displacement of a body moving in a straight line and time.



(a) Calculate the average velocity of the body from 1 s to 5 s.

(b) At which point in the graph, the instantaneous velocity is maximum ?

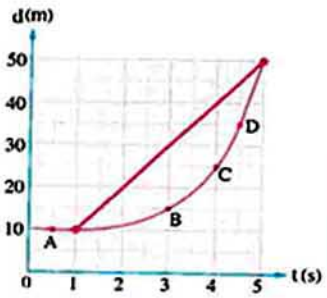
(c) At which point in the graph, the body is static ?

Solution

(a)

Clue

To determine the average velocity of a body during a certain time interval from the (displacement - time) graph, we draw a straight line from the starting point of this interval to its ending point and then we calculate the slope of this line.

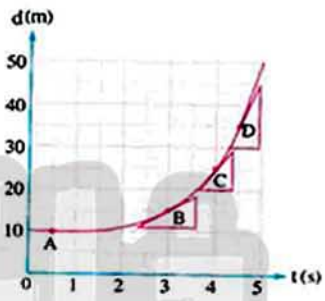


$$\bar{v} = \frac{\Delta d}{\Delta t} = \frac{d_f - d_i}{t_f - t_i} = \frac{50 - 10}{5 - 1} = 10 \text{ m/s}$$

(b)

Clue

The instantaneous velocity at a point is determined by the slope of the tangent at this point and as the tangent becomes steeper the instantaneous velocity becomes larger.



At point D, the instantaneous velocity is maximum.

(c)

Clue

The body becomes static when its displacement doesn't change with time, which means that the body's motion is represented by a straight line parallel to the x-axis (the tangent's slope of the (displacement - time) curve vanishes).

At point A, the body is static.

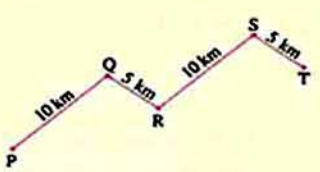
Test yourself

Choose :

1. A car is moving in a straight line, it covers 100 km in two hours. If the maximum velocity reached by the car during this journey was 90 km/h and the minimum velocity was 30 km/h, then its average velocity is .....

   (a) 30 km/h (b) 50 km/h (c) 60 km/h (d) 90 km/h

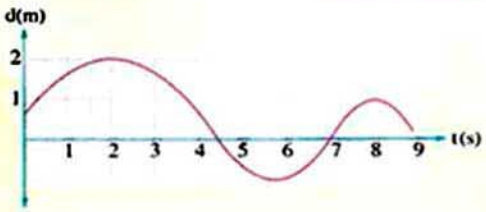
2. The opposite figure shows the path of a moving car. If the car covered this path in half an hour, then its average speed equals .....



   (a) 10 km/h (b) 20 km/h

   (c) 30 km/h (d) 60 km/h

3 The opposite graph describes the relation between the displacement of a moving body and the time, so at which time points will the body's instantaneous velocity equal zero ?



.....

.....

Practical Experiment

Determination of the velocity of a moving object.

1. Experiment Objectives :

- Observing the relation between the displacement of a toy car that is moving beside a ruler and the time of motion.
- Drawing the (displacement - time) graph for the motion of the car and calculating its speed from the graph.

2. Tools :

1. Electric car toy.
2. A meter ruler.
3. A digital camera.

3. Procedure :

1. Fix a metric ruler aside the path by which the car would pass.
2. Mount the camera facing the toy and the ruler and turn it on.
3. Place the car at the start line and allow it to move in a straight line parallel to the ruler.

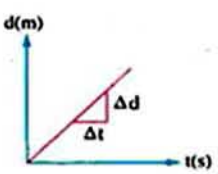
4. Determine the car position every 5 seconds by reading the metric ruler on the video display.
5. Record the results in a table as shown :

t (s)	0	5	10	15	20
d (m)	.....	.....	.....	.....	.....

6. Plot a graphical relationship between time (t) on the horizontal axis and displacement (d) on the vertical axis.

4. Conclusion :

When plotting the graphical relationship between displacement and time, a straight line is obtained passing through the origin and its slope equals the velocity of the car (v).



The slope of the line = $\frac{\Delta d}{\Delta t} = v$

QUESTIONS ON
Chapter 1
LESSON ONE

Motion

Interactive test

First Multiple choice questions

1. Which of the following is considered a translational motion ? ..... .


ⓐ

ⓑ

ⓒ

ⓓ

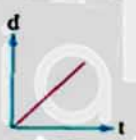
2. If the velocity is given by the relation : $v = \frac{d\ (\text{displacement})}{t\ (\text{time})}$ and a body's displacement is 20 m during 10 s, then the velocity of the body equals ..... .

ⓐ 200 m/s ⓑ 30 m/s ⓒ $\frac{1}{2}$ m/s ⓓ 2 m/s

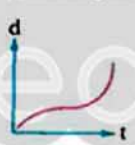
3. A leopard was chasing a prey, if it moves by a uniform velocity of 10 m/s during 15 s, then its displacement is ..... .

ⓐ 25 m ⓑ 150 m ⓒ 1.5 m ⓓ 200 m

4. Which of the following graphs describes a body moving at non-uniform velocity ? ..... .

ⓐ


ⓑ


ⓒ


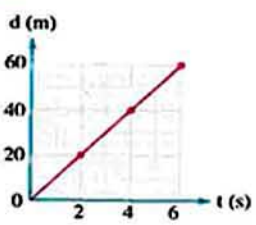
ⓓ

5. If a car is moving in a straight line to cover a distance of 300 m in a minute, the car's velocity is ..... .

ⓐ 300 m/s ⓑ 360 m/s ⓒ 240 m/s ⓓ 5 m/s

6. The opposite graph describes the motion of a body which is moving at ..... velocity of magnitude ..... .

ⓐ non-uniform , 10 m/s
ⓑ non-uniform , 40 m/s
ⓒ uniform , 10 m/s
ⓓ uniform , 40 m/s



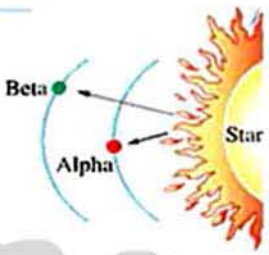
7 A man is running along a rectangular path of dimensions 50 m and 40 m. If he completes one revolution in a time of 100 s, then his average velocity equals ..... .

(a) 9 m/s (b) 1.8 m/s (c) 0.9 m/s (d) 0

8 The Earth orbits the Sun in a roughly circular path to complete one revolution in 365.25 days, if the radius of the Earth's orbit is 1.5×10^{11} m, then its speed around the Sun equals ..... .

(a) 90.1 km/s (b) 29.9 km/s (c) 15.2 km/s (d) 300 m/s

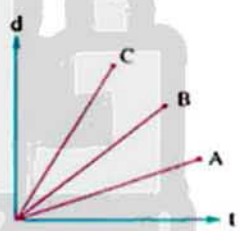
9 Light travels from the star to planet Alpha in fifteen minutes and travels from the star to planet Beta in one hour. If the velocity of light is 3×10^8 m/s, then the distance between the orbits of the two planets equals ..... .



(a) 81×10^{20} m (b) 81×10^{10} m

(c) 48×10^{8} m (d) 48×10^{11} m

10 The opposite graph describes the motion of three students A , B and C. If the three students start their motion from the school to reach their homes, then .....



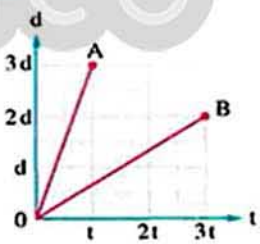
(a) The velocity of A > The velocity of B > The velocity of C

(b) The velocity of C > The velocity of B > The velocity of A

(c) The velocity of B > The velocity of C > The velocity of A

(d) The velocity of C = The velocity of B = The velocity of A

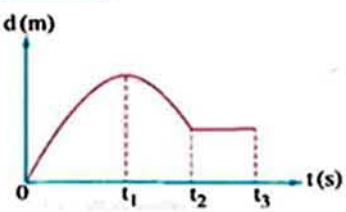
11 The opposite graph describes the motion of two bodies A and B, where the ratio between their velocities $\frac{v_A}{v_B}$ equals ..... .



(a) $\frac{2}{2}$ (b) $\frac{3}{2}$

(c) $\frac{9}{4}$ (d) $\frac{4}{3}$

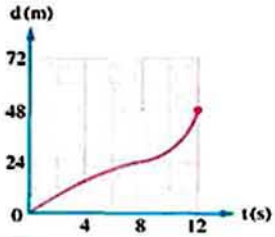
12 From the opposite (displacement - time) graph, the time interval at which the velocity is negative is between ..... .



(a) 0 , t_1 (b) t_1 , t_2

(c) t_2 , t_3 (d) t_1 , t_3

13 The opposite graph shows a part of the journey of a car which is moving in a straight road at a certain direction, what is the average velocity of the car during 12 s ? ..... .

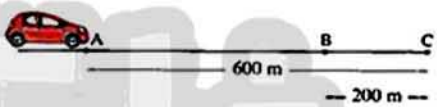


(a) 2 m/s (b) 4 m/s
(c) 2.5 m/s (d) 5 m/s

14 If a body moves along a curved path, the ratio between its average speed and its average velocity will be ..... .

(a) greater than one
(b) less than one
(c) equal to one
(d) we can't determine the answer, unless we know the time of motion

15 The opposite figure shows a car that starts its motion from rest at point A to reach point C after 80 s, then it returns back in the opposite direction to reach point B after 20 s, so the average velocity of the car in the following intervals equals ..... .



	From t = 0 to t = 80 s	Through the whole journey
(a)	4 m/s	6 m/s
(b)	8 m/s	4 m/s
(c)	7.5 m/s	8 m/s
(d)	7.5 m/s	4 m/s

16 If a car covered 30 km in the south direction during 0.5 h, then it covered 40 km in the east direction during 2.5 h, so :

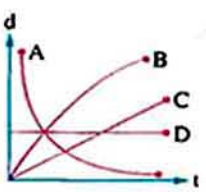
(i) The average velocity of the car equals ..... .

(a) 8.24 km/h (b) 12.54 km/h (c) 16.67 km/h (d) 18.22 km/h

(ii) The average speed of the car equals ..... .

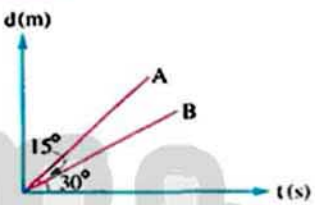
(a) 16.67 km/h (b) 23.33 km/h (c) 25.21 km/h (d) 27.42 km/h

17 The opposite graph describes the motion of four students relative to their school. Which of the following choices describes their motion accurately ? ..... .



	Student A	Student B	Student C	Student D
(a)	Non-uniform velocity.	Non-uniform velocity.	Static.	Uniform velocity.
(b)	Moving towards the school.	Moving away from the school.	Uniform velocity.	Static.
(c)	Uniform velocity.	Static.	Moving away from the school.	Moving towards the school.
(d)	Static.	Moving towards the school.	Non-uniform velocity.	Moving away from the school.

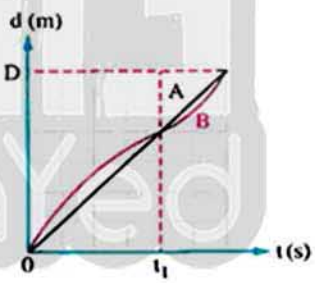
18 The opposite graph shows the relation between the displacement and time for two bodies A and B that start their motion from rest, so the ratio between the velocity of A and the velocity of B is ..... .



(a) 0.46 (b) 2.15

(c) $\sqrt{3}$ (d) $\sqrt{2}$

19 The opposite graph shows the relation between the displacement and the time of two cars A and B that start a race at t = 0 and move in a straight line to cover a displacement D. Which of the following statements is wrong ? ..... .



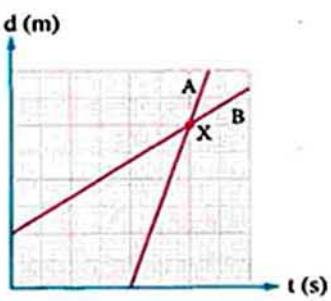
(a) Car A moves with a uniform velocity, while car B moves with non-uniform velocity

(b) Car A reaches the end of the race first

(c) At time t_1, the average velocity of car A equals the average velocity of car B

(d) The two cars cover the same displacement after time t_1

20 The opposite graph describes the motion of two boys A and B moving at a uniform velocity. Which of the following sentences is right ? ..... .



(a) B starts his motion after A

(b) The velocities of A and B are equal at point X

(c) The velocity of A is less than that of B

(d) A precedes B after passing point X

21 A body moves along a straight line at velocity v to cover a distance d, then it moves along the same straight line at velocity 2 v to cover a distance 4 d, so its average velocity equals ..... .

(a) v (b) $\frac{3}{2}$ v (c) 2 v (d) $\frac{5}{3}$ v

22 A car is moving in a straight road for time t by an average velocity v, then it moves for time 2 t by an average velocity 2 v. So its total average velocity is ..... .

(a) v (b) 2 v (c) $\frac{3}{2}$ v (d) $\frac{5}{3}$ v

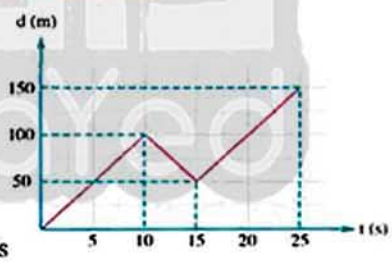
23 A car was moving in a straight road of length 320 km, it covered 240 km with an average velocity of 75 km/h, then it ran out of fuel and stopped for 0.6 h until it was refueled and completed its journey with a velocity of 100 km/h. So the average velocity of the car during the whole journey was ..... .

(a) 69.57 km/h (b) 80 km/h (c) 87.57 km/h (d) 95 km/h

24 If a car is moving in a straight road to cover one third of the distance at velocity of 25 km/h and the rest of the distance was covered at velocity of 75 km/h, so the average velocity of the car is ..... km/h.

(a) 65 (b) 50 (c) 45 (d) 30

25 A cyclist takes a ride lasting 25 s. The diagram shows how the distance which is travelled by her from the starting position varies with time.



(i) What is her average velocity for the whole ride ? ..... .

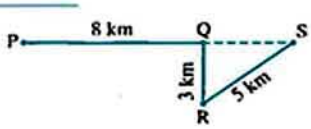
(a) 6 m/s (b) 7.5 m/s

(c) 10 m/s (d) 11 m/s

(ii) What is the average speed for the whole ride ? ..... .

(a) 6 m/s (b) 7.5 m/s (c) 10 m/s (d) 11 m/s

26 A lorry takes 15 minutes to travel along the path PQRS.



(i) What is the average speed of the lorry ? ..... .

(a) 4 km/h (b) 22 km/h (c) 48 km/h (d) 64 km/h

(ii) What is the average velocity of the lorry ? ..... .

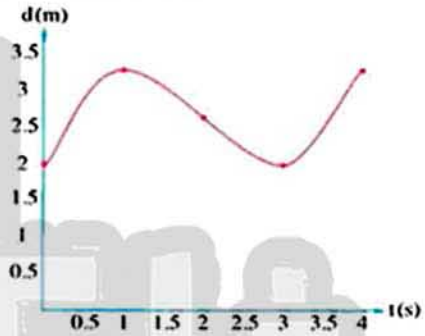
(a) 4 km/h (b) 22 km/h (c) 48 km/h (d) 64 km/h

27 A car travelled 100 km along a main road with an average speed of 83.3 km/h then it travelled for 42 minutes along a side road with an average speed of 56 km/h as shown in the opposite diagram. What is the average speed of the car for the whole journey ? ..... .

(a) 63.3 km/h (b) 72.75 km/h (c) 76.6 km/h (d) 89.7 km/h

28 The following graph describes the motion of an object, based on this graph at which time points will the object's velocity be closest to zero ? ..... .

(a) 0 s and 2 s
(b) 0 s and 4 s
(c) 1 s and 3 s
(d) 2 s and 4 s

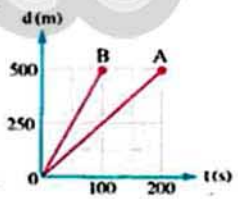


Second Essay questions

1 Mention the conditions for an object to move at a uniform velocity.

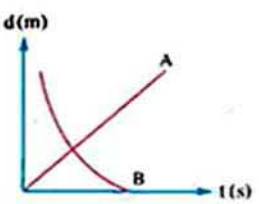
2 If the average velocity of a body during a certain time interval equals zero. What can you say about the displacement of the body during this interval ?

3 **In the opposite figure :**
Two objects (A) and (B) have moved from rest.
Which object has been faster? And why?



4 The opposite diagram represents the motion of two objects (A) and (B) relative to a building.

(a) Which of them has moved away from the building and which got closer to the building?
(b) Which of them has moved at a uniform velocity and which has moved at a non-uniform velocity? Explain your answer.
(c) Which of them has reached the end of its represented motion first?



5 When a space craft moves with uniform velocity, at which instant will its instantaneous velocity be equal to its average velocity ?

6 A car was moving in a straight road, at t = 0 the driver saw a barrier on the road so he pressed the brakes. The opposite figure represents the relation between the velocity of the car and the time :

(a) **Describe** the velocity of the car during the intervals ab and bc.

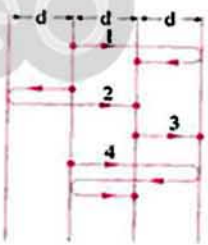
(b) **Calculate** the displacement covered by the car from t = 0 to t = 3.5 s

7 The opposite figure shows two girls trying to measure the velocity of the river's water. The girl that stands on the first bridge drops a piece of wood in the water and the girl that stands on the second bridge measures the time (t) taken by the piece of wood to reach the second bridge :

(a) **Mention** the suitable tools that can be used by the girls to measure the distance between the two bridges and also the time (t).

(b) If the time taken by the wooden piece to cover the distance between the two bridges is 400 s, **calculate** the velocity of the river's water.

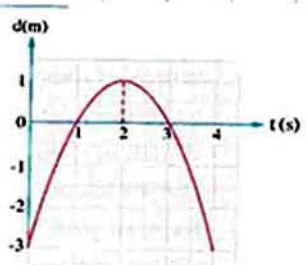
8 The opposite figure shows the motion path of four bodies through the same interval of time. **Arrange the four paths in descending order according to the magnitude of their :**



(a) average velocity.

(b) average speed.

9 The opposite (displacement - time) graph describes the motion of a body moving in a straight line. **Is the velocity of the body positive, negative or zero at :**



(a) t = 1 s

(b) t = 2 s

(c) t = 3 s

10 **Compare between** the average velocity and the average speed of a man moving in a straight line in the direction of :

(a) the east to cover a displacement d.

(b) the east to cover a displacement d and then he reverses his direction to cover a displacement d.

(c) the west to cover a displacement d and then he reverses his direction to cover a displacement $\frac{d}{2}$.

11 At t = 0, a girl starts to swim from one of the ends of a swimming pool of length ℓ to reach the other end after time t_1, then she swims backwards to reach the starting point again after time t_2. Assume that the primary direction of the girl in swimming is the positive direction of x-axis :

(a) **Find her average velocity during :**

1- the first interval of swimming. 2- the second interval of swimming.

3- the whole interval of swimming.

(b) **Calculate** the average speed of the girl during the whole interval of swimming.

12 The opposite (displacement - time) graph describes the motion of a girl riding a bike :

(a) **Describe** the velocity of the girl during the intervals AB , BC and CD in figure (1).

(b) **Add** to figure (2) a line that represents the velocity of the girl during the intervals AB , BC and CD.

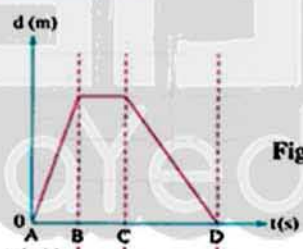


Figure (1)

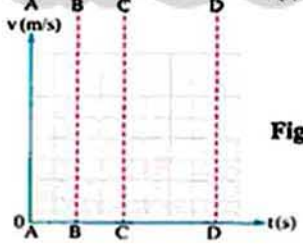
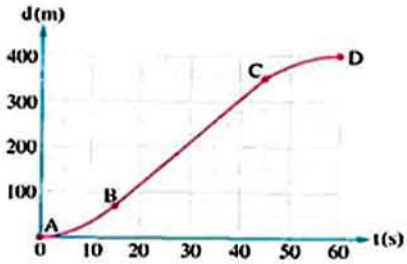


Figure (2)

UNIT 2

13 The opposite graph describes the motion of a girl riding a bike and moving in a straight road :



(a) **Describe** the motion of the girl through the intervals AB , BC and CD.

(b) **Calculate** the average velocity of the girl from A to D.

(c) **Calculate** the maximum velocity reached by the girl.

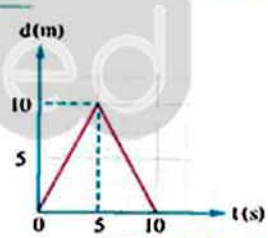
Third Problems

1 A car moves in a straight road at a uniform velocity so that it passes by the (151 km) sign at 8:00 am and by the (316 km) sign at 10:00 am. **Find** the velocity of the car. (22.9 m/s)

2 **Calculate** the time required for the sunlight to reach the Earth's surface, if the distance between the Sun and the Earth is 1496×10^5 km and the speed of light in space is 3×10^8 m/s. (498.67 s)

3 A student left his home at 8 : 00 am to go to the school which is 1.5 km from his home. If he arrived the school at 8 : 45 am, **find** his average speed in km/h. (2 km/h)

4 **Use the opposite graph to find :**



(a) The total distance.

(b) The object displacement.

(c) The velocity in the first five seconds.

(20 m, 0, 2 m/s)

5 In a football match, the ball was 50 m away from a player who was running at 3 m/s, meanwhile another player was at 35 m from the ball and ran at 2 m/s towards the ball. **Who** would reach the ball first? (The first player)

6 A student was participating in the annual race of the school, the race is of distance 6 km. The student wishes to break the record of the fastest competitor which is 26 minutes. The race begins and ends down the clock tower of the school, if the race begins when the clock tower is as in figure (1) and ends when the clock tower is as in figure (2) :

Figure (1)

Figure (2)

(a) **Does** the student break the record ?

(b) **Calculate** the average speed of the student during the race. (4 m/s)

7 Your father and his friend start driving their cars from the same starting point, where your father rides with a velocity of 90 km/h and his friend rides with a velocity of 95 km/h. If your father's friend reaches the end of the journey first after travelling a distance 50 km, **how much time** will he wait until your father reaches this ending point ? (1.74 min.)

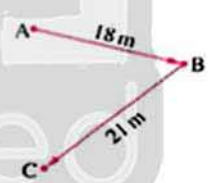
8 A body is moving according to this relation : $x = 10\ t^2$, where x is measured in meters and t is measured in seconds. **Calculate** the average velocity from :

(a) 2 s to 3 s.

(b) 2 s to 2.1 s.

(c) **Does** the body move with a uniform velocity ? (50 m/s , 41 m/s)

9 The opposite figure shows the path of a football that was kicked between three players on a playground, if the ball moves from player A to player B in 1.2 s :



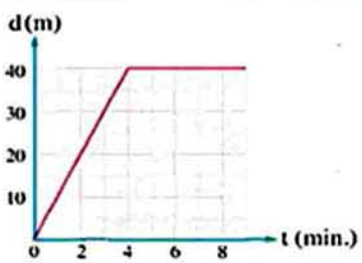
(a) **Calculate** the average velocity of the ball between A and B.

(b) **Calculate** the time taken by the ball to move from B to C, if it has the same magnitude of the average velocity as in (A).

(c) **Discuss** if the average velocity between A and B is the same between B and C or not.

(15 m/s , 1.4 s)

10 The following diagram represents the relation between the displacement and time for the motion of a car.



(a) **What** is the instantaneous velocity after 1 minute?

(b) **What** is the instantaneous velocity after 6 minutes?

(c) **What** is the average velocity after 8 minutes?

(d) **Describe** the car's motion during 8 minutes.

(0.167 m/s , zero , 0.083 m/s)

11 The opposite figures represent the path of two bodies, the first body started from (A) and returned back in 9 s and the second body started from (B) to reach (C) after 4 hours. **Find :**

(a) The distance covered by each body.

(b) The displacement covered by each body.

(c) The average speed of each body.

(d) The average velocity of each body.

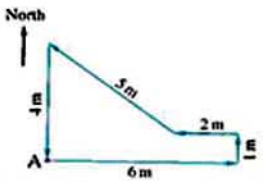


Figure (1)

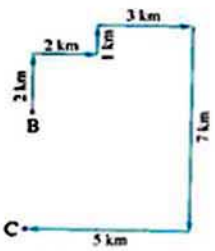
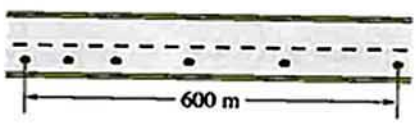


Figure (2)

(18 m, 20 km, 0.4 km south, 2 m/s, 5 km/h, 0, 1 km/h south)

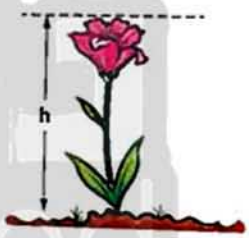
12 A car is moving on a straight road, where its engine drops an oil drop every 5 s on the road as shown on the figure. **Calculate** the average velocity of the car during the distance shown in the figure.



(24 m/s)

13 A botanist studies the growth of one of his plants by measuring the height (h) of the plant from the surface of the ground everyday at the same time and the next table shows his results :

t (days)	0	1	2	3	4	5	6	7
h (cm)	2.1	6.5	11.4	18.4	24.5	26.7	30.7	37.1



Calculate the average velocity of the plant's growth during 7 days.

(5 cm/day)

14 The opposite graph shows the change of displacement with time for a body moving in a straight line :

(a) **Calculate the average velocity of the body during the following intervals :**

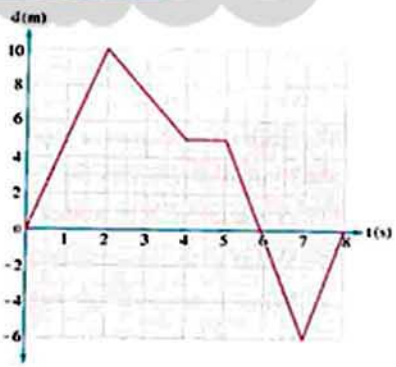
1- from 0 to 2 s.

2- from 0 to 4 s.

3- from 2 s to 4 s.

4- from 4 s to 7 s.

5- from 0 to 8 s.



(b) **Calculate the instantaneous velocity of the body at :**

1- 1 s. 2- 3 s. 3- 4.5 s. 4- 7.5 s

(5 m/s , 1.25 m/s , –2.5 m/s , –3.67 m/s , 0 , 5 m/s , –2.5 m/s , 0 , 6 m/s)

15 Two children (A) and (B) start to run towards each other when the distance between them was 135 m. If the velocity of child (A) is 6.75 m/s and the velocity of child (B) is 5.25 m/s, **find** the distance covered by each child until they meet. (75.94 m, 59.06 m)

16 A girl is walking in a straight line from point A to point B with a velocity of 5 m/s, then she returns back from point B to point A along the same straight line with a velocity of 3 m/s. **Calculate :**

(a) The average speed during the whole journey.

(b) The average velocity during the whole journey. (3.75 m/s , 0)

17 (a) **Calculate the average velocity in the following cases :**

1- A body moves in a straight line with a velocity of 10 m/s for a distance of 100 m, then it moves a distance of 100 m with a velocity of 20 m/s.

2- A body moves in a straight line for one minute with a velocity of 10 m/s, then it moves another minute with a velocity of 20 m/s.

(b) **Plot** the (displacement - time) graphs of the previous cases, by showing on the graphs how to find the average velocity in both cases. (13.33 m/s , 15 m/s)

18 A woman walks for 4 minutes in the north direction with an average velocity of 6 km/h; then she walks eastward at 4 km/h for 10 minutes. **Find :**

(a) Her average speed for the trip.

(b) The average velocity for the entire trip. (4.57 km/h, 3.334 km/h)

19 The table below illustrates the relation between displacement (d) of a car and time (t) :

t (s)	1	2	3	4	5	C
d (m)	4	8	A	16	B	28

(a) **Plot** the graphical relation between (d) on the vertical axis and (t) on the horizontal axis.

(b) **From the graph find :**

1- The values of A , B and C.

2- The velocity of the car.

3- The type of the velocity of the car. (12 m, 20 m, 7 s, 4 m/s, uniform velocity)

Chapter 1

LESSON TWO

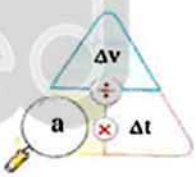
Acceleration

If the velocity of an object is changed from one point to another either in magnitude or in direction, this change in velocity with time (rate of change of velocity) is known as **acceleration** and such motion is called **accelerated motion**.

- The acceleration can be found by the relation :

$$\text{Acceleration} = \frac{\text{Change in velocity}}{\text{Time of change}} = \frac{\text{Final velocity} - \text{Initial velocity}}{\text{Final time} - \text{Initial time}}$$

$$a = \frac{\Delta v}{\Delta t} = \frac{v_2 - v_1}{t_2 - t_1}$$



- The unit of measuring acceleration is m/s^2 or km/h^2 and its dimensional formula is LT^{-2}

Types of acceleration

1 Uniform acceleration

It is the acceleration in which the object changes its velocity with **equal amounts** in equal intervals of time.

2 Non-uniform acceleration

It is the acceleration in which the object changes its velocity with **unequal amounts** in equal intervals of time.

Example

When a car is moving according to the data in the table below :

v (m/s)	0	10	20	30	40	50
t (s)	0	1	2	3	4	5

$$a_1 = \frac{v_2 - v_1}{t_2 - t_1} = \frac{10 - 0}{1 - 0} = 10 \text{ m/s}^2$$

$$a_2 = \frac{v_3 - v_2}{t_3 - t_2} = \frac{20 - 10}{2 - 1} = \frac{10}{1} = 10 \text{ m/s}^2$$

$$a_3 = \frac{v_4 - v_3}{t_4 - t_3} = \frac{30 - 20}{3 - 2} = \frac{10}{1} = 10 \text{ m/s}^2$$

$$a_4 = \frac{v_5 - v_4}{t_5 - t_4} = \frac{50 - 40}{5 - 4} = 10 \text{ m/s}^2$$

When a car is moving according to the data in the table below :

v (m/s)	0	10	18	30	50
t (s)	0	4	6	8	10

$$a_1 = \frac{v_2 - v_1}{t_2 - t_1} = \frac{10 - 0}{4 - 0} = 2.5 \text{ m/s}^2$$

$$a_2 = \frac{v_3 - v_2}{t_3 - t_2} = \frac{18 - 10}{6 - 4} = \frac{8}{2} = 4 \text{ m/s}^2$$

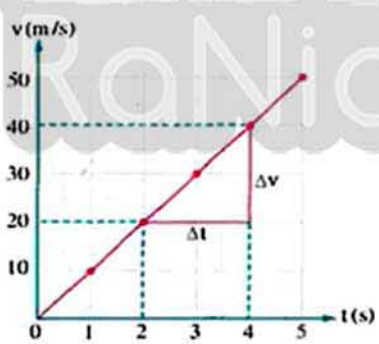
$$a_3 = \frac{v_4 - v_3}{t_4 - t_3} = \frac{30 - 18}{8 - 6} = \frac{12}{2} = 6 \text{ m/s}^2$$

$$a_4 = \frac{v_5 - v_4}{t_5 - t_4} = \frac{50 - 30}{10 - 8} = \frac{20}{2} = 10 \text{ m/s}^2$$

Graphical representation

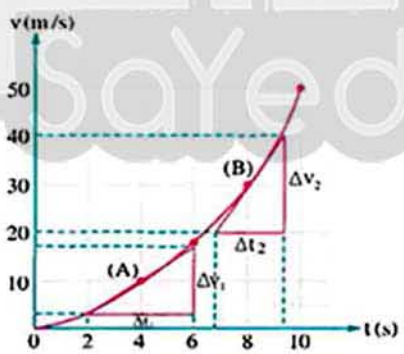
When plotting the relation between velocity (v) on the ordinate (y-axis) and time (t) on the abscissa (x-axis), we may get :

A straight line



The slope of the straight line gives the uniform acceleration by which the object moves.

A curve



The slope of the tangent drawn to the curve at any point gives the instantaneous acceleration of the object at this point.

Slope of line = $a = \frac{\Delta v}{\Delta t} = \frac{40 - 20}{4 - 2}$

$= 10\ m/s^2$

• The acceleration at t = 4 s

Slope at (A) = $a_{(A)} = \frac{\Delta v_1}{\Delta t_1} = \frac{17 - 3}{6 - 2}$

$= 3.5\ m/s^2$

• The acceleration at t = 8 s

Slope at (B) = $a_{(B)} = \frac{\Delta v_2}{\Delta t_2} = \frac{40 - 20}{9.4 - 6.8}$

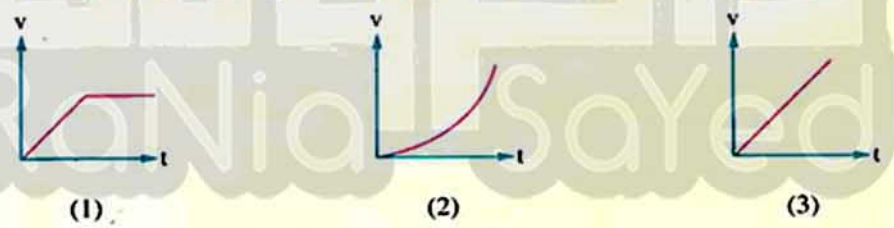
$= 7.69\ m/s^2$

This means that

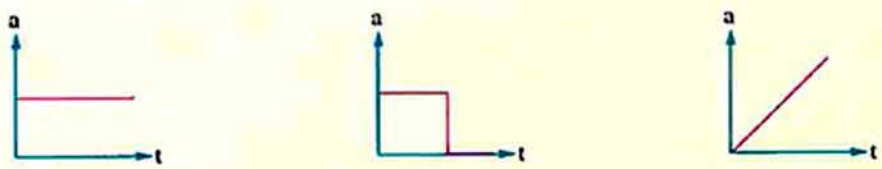
- The velocity of the object changes with equal amounts in equal intervals of time and this is called **uniform acceleration.**
- The velocity of the object changes with unequal amounts in equal intervals of time and this is called **non-uniform acceleration** (changeable acceleration).

1 Test yourself

Match the (velocity - time) graphs with their (acceleration - time) graphs :



(1) (2) (3)



(a) (b) (c)

.....

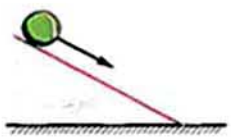
.....

If we assume that the velocity of an object is positive, its acceleration may be :

1. Positive (increasing velocity).
2. Equal zero (uniform velocity).
3. Negative and in this case it is called **deceleration** (decreasing velocity).

1 Positive acceleration

It is the acceleration of the object when its velocity increases with time.



Example

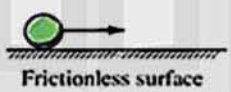
When an object moves according to the table below :

v (m/s)	0	10	20	30	40
t (s)	0	1	2	3	4

$$a_1 = \frac{v_2 - v_1}{t_2 - t_1}$$
$$= \frac{10 - 0}{1 - 0}$$
$$= 10 \text{ m/s}^2$$
$$a_2 = \frac{v_3 - v_2}{t_3 - t_2}$$
$$= \frac{20 - 10}{2 - 1}$$
$$= 10 \text{ m/s}^2$$

2 Zero acceleration

It is the acceleration when the velocity of the object is constant with time.



Example

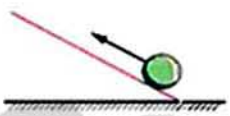
When an object moves according to the table below :

v (m/s)	20	20	20	20	20
t (s)	0	1	2	3	4

$$a_1 = \frac{v_2 - v_1}{t_2 - t_1}$$
$$= \frac{20 - 20}{1 - 0}$$
$$= 0$$
$$a_2 = \frac{v_3 - v_2}{t_3 - t_2}$$
$$= \frac{20 - 20}{2 - 1}$$
$$= 0$$

3 Negative acceleration

It is the acceleration of the object when its velocity decreases with time.



Example

When an object moves according to the table below :

v (m/s)	50	40	30	20	10
t (s)	0	1	2	3	4

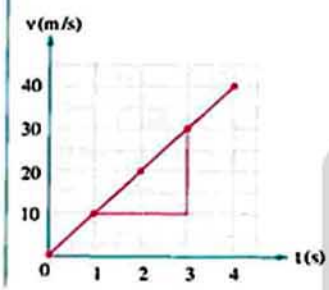
$$a_1 = \frac{v_2 - v_1}{t_2 - t_1}$$
$$= \frac{40 - 50}{1 - 0}$$
$$= -10 \text{ m/s}^2$$
$$a_2 = \frac{v_3 - v_2}{t_3 - t_2}$$
$$= \frac{30 - 40}{2 - 1}$$
$$= -10 \text{ m/s}^2$$

UNIT 2

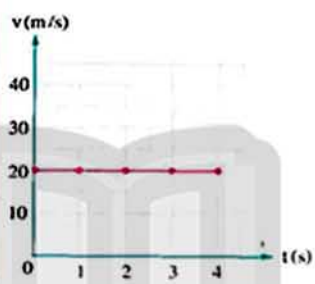
Graphical representation

When plotting the graphical relationship of (velocity - time), we may get :

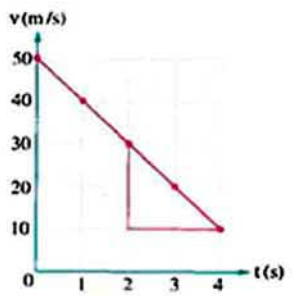
- A straight line that may start from the origin.



- A straight line parallel to the time axis.



- A straight line that may end at the time axis.



By finding the slope of the straight line, we obtain the acceleration of the object motion :

Slope of line = $a = \frac{\Delta v}{\Delta t}$ $= \frac{30 - 10}{3 - 1} = 10\ m/s^2$

Slope of line = $a = 0$

Slope of line = $a = \frac{\Delta v}{\Delta t}$ $= \frac{10 - 30}{4 - 2} = -10\ m/s^2$

This means that

- The velocity of the object **increases** with time, so the object moves with uniform **positive acceleration** of 10 m/s^2.
- The velocity of the object is uniform (**constant**) with time, so the object moves with no acceleration (**zero acceleration**).
- The velocity of the object **decreases** with time, so the object moves with uniform **negative acceleration** of – 10 m/s^2.

Guidelines to solve problems

1. If the object moves at uniform velocity, its acceleration of motion = zero because the change in velocity (Δv) = zero
2. When the object starts motion from rest, its initial velocity (v_i) = zero and when the object comes to rest, its final velocity (v_f) = zero
3. If the object moves in a straight line with uniform acceleration, its average velocity is given from the relation : $\bar{v} = \frac{v_i + v_f}{2}$
4. If the driver applies the brakes till the car stops, its final velocity (v_f) = zero
5. When the final velocity (v_f) > the initial velocity (v_i), the acceleration is positive (increasing velocity).

6. When the final velocity (v_f) < the initial velocity (v_i), the acceleration is negative (decreasing velocity).
7. When the final velocity (v_f) = the initial velocity (v_i), the acceleration is zero (uniform velocity).
8. If the velocity and acceleration have the same direction then they have the same sign (accelerating motion).
9. If the velocity and acceleration have opposite directions then they have opposite signs (decelerating motion).

Example 1

A car was moving at velocity 30 m/s. When the driver applied the brakes, the car stopped within 15 s. Find :

(a) The acceleration of the car. *(b)* The type of acceleration clarifying the reason.

Solution

Clue

The initial velocity is the velocity by which the car was moving directly before applying the brakes, so the initial velocity equals 30 m/s and the final velocity equals zero because the car comes to rest.

$v_i = 30$ m/s | $v_f = 0$ | $\Delta t = 15$ s | $a = ?$

(a) $\Delta v = v_f - v_i = 0 - 30 = -30$ m/s

$$a = \frac{\Delta v}{\Delta t} = \frac{-30}{15} = -2 \text{ m/s}^2$$

(b) The acceleration is negative (deceleration).

Because the final velocity (v_f) < The initial velocity (v_i)

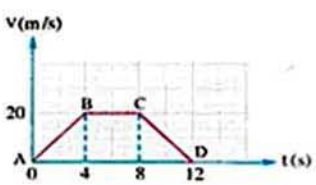
Example 2

From the opposite graph :

(a) Describe the type of motion by which the body moves within 12 s.

(b) Calculate the acceleration in each part.

(c) Calculate the distance covered by the body through its motion from B to C.



Solution

Clue

The slope of the line in the (velocity - time) graph represents the body's acceleration. If the slope is positive, the acceleration is positive and if the slope is negative, the acceleration is negative and if the slope equals zero, the acceleration equals zero.

(a) - During the first 4 s the body is moving with a positive uniform acceleration.
- During the second 4 s the body is moving with a uniform velocity (zero acceleration).
- During the last 4 s the body is moving with a uniform deceleration (negative acceleration).

(b) - From A to B :

$$a = \frac{\Delta v}{\Delta t} = \frac{v_f - v_i}{\Delta t} = \frac{20 - 0}{4 - 0} = \frac{20}{4} = 5 \text{ m/s}^2$$

- From B to C :

$$a = 0$$

- From C to D :

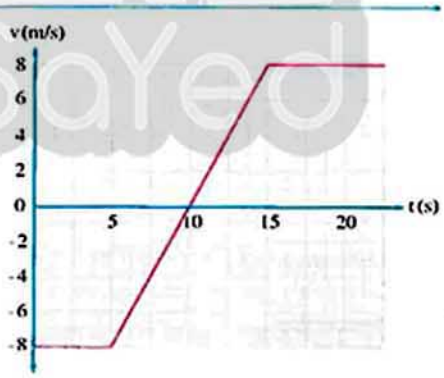
$$a = \frac{\Delta v}{\Delta t} = \frac{0 - 20}{12 - 8} = \frac{-20}{4} = -5 \text{ m/s}^2$$

(c) $s = v\Delta t$

$= 20 \times (8 - 4) = 80$ m

Example 3

The opposite graph shows the relation between the velocity of a body that moves in a straight line and the time :



(a) Calculate the acceleration of the body from t = 5 s to t = 15 s

(b) Plot on a graph paper the relation between the acceleration of the body and the time.

Solution

(a)

Clue

The acceleration of the body equals the slope of the (velocity - time) curve.

$$a = \frac{\Delta v}{\Delta t} = \frac{8 - (-8)}{15 - 5} = \frac{16}{10} = 1.6 \text{ m/s}^2$$

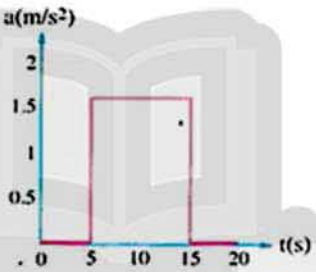
(b)

Clue

To draw the (acceleration - time) graph for the moving body, we should calculate the slope of the (velocity - time) graph at the following time intervals :

- *From t = 0 to t = 5 s : a = Slope = 0*
- *From t = 5 s to t = 15 s : a = Slope = 1.6 m/s²*
- *From t = 15 s to t = 20 s : a = Slope = 0*

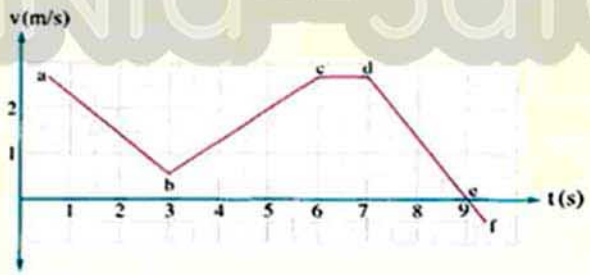
Then we plot the results :



2 Test yourself

The next graph shows the relation between the velocity of a body that moves in a straight line and the time. Mention the time intervals at which the body's acceleration is :

(a) positive. **(b) negative.** **(c) zero.**



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QUESTIONS ON
Chapter 1
LESSON TWO

Acceleration

Interactive test

First Multiple choice questions

1. If a body starts its motion from rest and moves by acceleration (a) to reach a velocity (v_f) after time (t), so its final velocity (v_f) can be represented by the relation : .....

ⓐ $v_f = \frac{a}{t}$ ⓑ $v_f = at$ ⓒ $v_f = \frac{1}{2} at^2$ ⓓ $v_f = \sqrt{at}$

2. If the acceleration is represented by the relation : $a = \frac{\Delta v}{\Delta t}$, then the change in the velocity of a body that is affected by an acceleration 4 m/s^2 during 2 s is ..... .

ⓐ 6 m/s ⓑ 8 m/s ⓒ 10 m/s ⓓ 12 m/s

3. A body is moving with a uniform velocity of 5 m/s for 5 s, then its acceleration equals ..... .

ⓐ 5 m/s^2 ⓑ 1 m/s^2 . ⓒ zero ⓓ – 5 m/s^2

4. If an object starts motion from rest and speeds up at a constant rate till its velocity becomes 50 m/s during 10 s, this motion is at acceleration of ..... .

ⓐ 60 m/s^2 ⓑ $\frac{1}{5}$ m/s^2 ⓒ 5 m/s^2 ⓓ 40 m/s^2

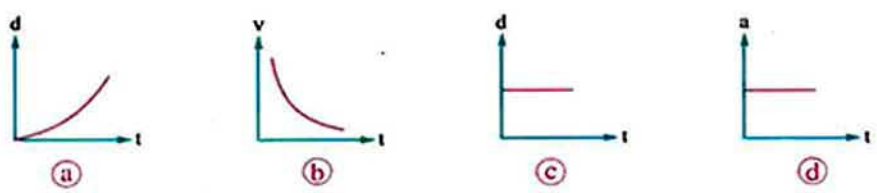
5. In positive acceleration, ...

ⓐ initial velocity > final velocity ⓑ initial velocity < final velocity
ⓒ initial velocity = final velocity ⓓ velocity is constant

6. In the opposite figure, the car moves by ..... uniform acceleration.

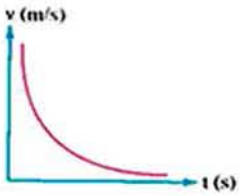
ⓐ positive ⓑ negative
ⓒ zero ⓓ we can't determine the answer.

7. The following graphs describe a body moving with an acceleration except ..... .



ⓐ ⓑ ⓒ ⓓ

8 The opposite graph describes the motion of a body moving with an acceleration, then the velocity of the body ..... .



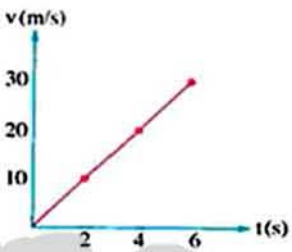
(a) increases by uniform rate

(b) increases by non-uniform rate

(c) decreases by uniform rate

(d) decreases by non-uniform rate

9 The opposite graph shows the relation between the body's velocity (v) and the time (t), then the body moves by ..... .



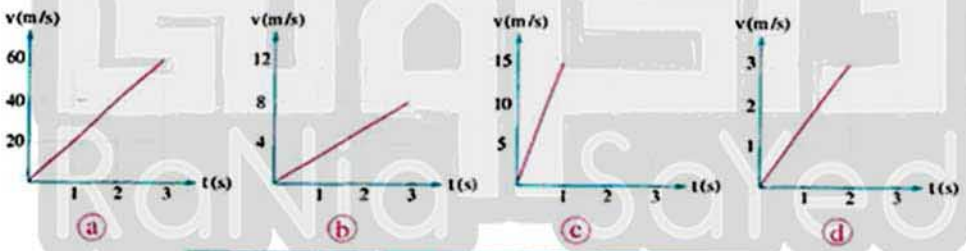
(a) uniform acceleration of $+10\ m/s^2$

(b) uniform acceleration of $-5\ m/s^2$

(c) uniform acceleration of $+5\ m/s^2$

(d) non-uniform acceleration of $-10\ m/s^2$

10 The following graphs describe objects moving with uniform acceleration, which object of them has the largest acceleration ? ..... .



11 A car took 4 seconds to have a velocity nine times its initial velocity. The acceleration of its motion is numerically equal to ..... its initial velocity.

(a) a half (b) double (c) three times (d) four times

12 When the object's acceleration is in the opposite direction to its velocity, its ..... .

(a) instantaneous velocity equals its average velocity

(b) velocity increases (c) velocity decreases

(d) displacement equals zero

13 If both the directions of velocity and acceleration are negative, ...

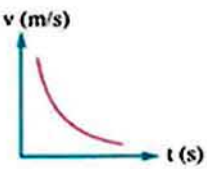
(a) velocity of the object increases (b) velocity of the object decreases

(c) velocity of object is constant (d) the object stops motion

14 A man starts his motion from rest with uniform acceleration of 1 m/s^2. If his average velocity is 1 m/s, then the time of his motion is ..... .

ⓐ 1 s ⓑ 2 s ⓒ 4 s ⓓ $\frac{1}{2}$ s

15 The opposite graph represents the relation between the velocity (v) and the time (t) of a car moving with ..... acceleration.

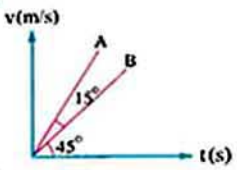


ⓐ positive uniform ⓑ negative non-uniform

ⓒ positive uniform acceleration then with negative uniform

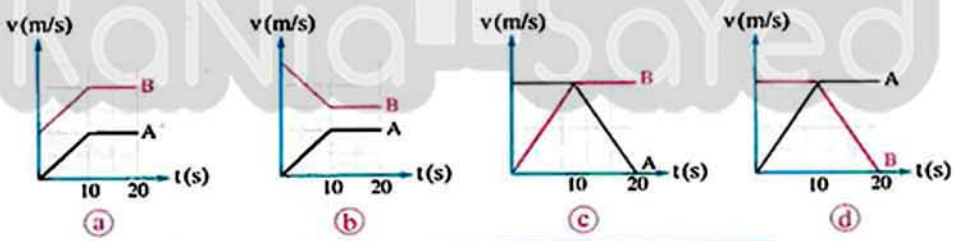
ⓓ negative non-uniform acceleration then with positive uniform

16 The opposite graph shows the relation between velocity (v) and time (t) of two bodies A and B that start their motion from rest, so the ratio between the accelerations of body A and body B is ..... respectively.

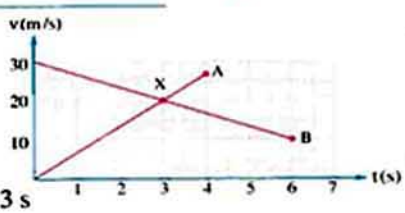


ⓐ $\frac{4}{3}$ ⓑ $\frac{1}{3}$ ⓒ $\frac{\sqrt{3}}{1}$ ⓓ $\frac{\sqrt{2}}{1}$

17 The car A starts its motion from rest with uniform acceleration of 1 m/s^2 in the first 10 s of the journey, while the car B moves with constant velocity of 10 m/s in the same time. In the next 10 s the car A moves with constant velocity of 10 m/s, while the car B decelerates by 1 m/s^2. So, the graph that represents the relation between the velocity and the time of the two cars is ..... .



18 The opposite figure represents the relation between the velocities of two objects A , B and time, so which of the following sentences is right ? ..... .



ⓐ A and B move in opposite directions from t = 0 to t = 3 s

ⓑ The accelerations of A and B are in the same direction

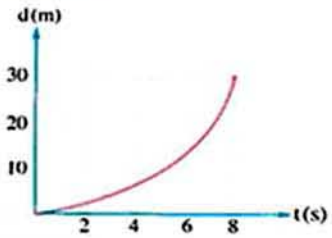
ⓒ The acceleration of A is larger than that of B

ⓓ The two objects meet at the same position after 3 s

19 A body starts its motion from rest and moves at uniform acceleration if its average velocity at time (t) was 10 m/s, then its average velocity at time (2 t) will be ..... .

(a) 10 m/s (b) 20 m/s (c) 30 m/s (d) 40 m/s

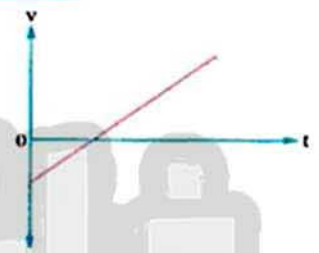
20 The opposite graph describes the motion of a body that starts its motion from rest and moves by uniform acceleration of ..... .

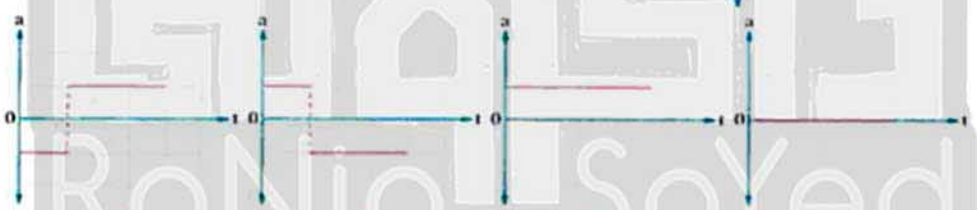


(a) 30 m/s^2 (b) 15 m/s^2

(c) $\frac{15}{16}$ m/s^2 (d) $\frac{15}{4}$ m/s^2

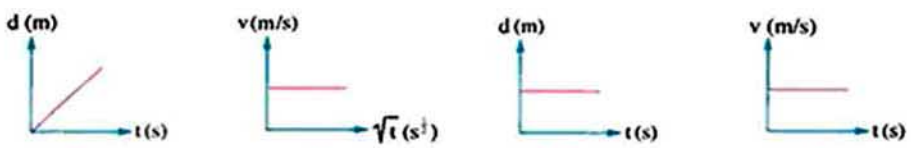
21 The opposite graph shows the relation between the velocity and the time of a body, which of the following graphs describes the change of the body's acceleration with time ? ..... .





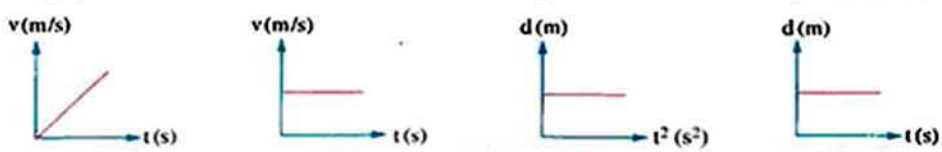
(a) (b) (c) (d)

22 The graph labeled ..... represents a motionless object.



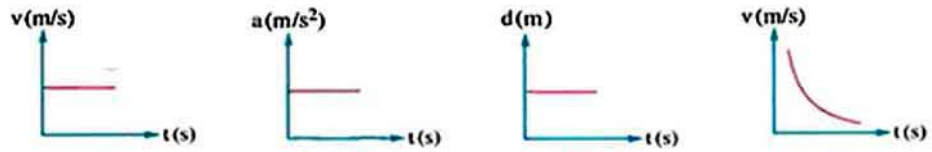
(a) (b) (c) (d)

23 The graph that best describes the motion of an object at uniform velocity is ..... .



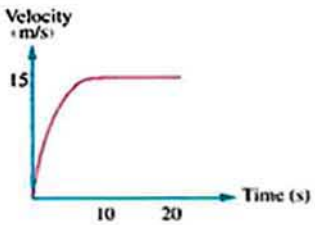
(a) (b) (c) (d)

24 The graph labeled ..... represents a body moving with positive uniform acceleration.



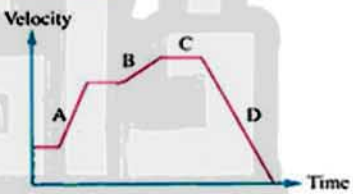
ⓐ ⓑ ⓒ ⓓ

25 The graph shows how the velocity of a car varies with time. Which statement about the acceleration of the car between 10 s and 20 s is correct ? ..... .



ⓐ The acceleration decreases
ⓑ The acceleration increases
ⓒ The acceleration is constant, but doesn't equal zero
ⓓ The acceleration equals zero

26 The graph shows how the velocity of a car travelling in a straight line changes with time. Which section shows the largest acceleration ? ..... .

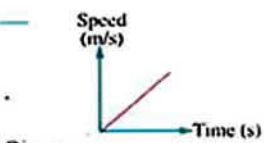


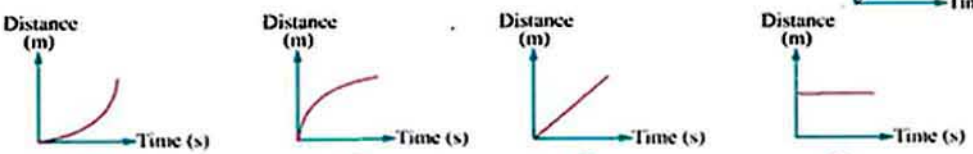
ⓐ Section A ⓑ Section B
ⓒ Section C ⓓ Section D

27 The opposite (velocity - time) graph represents the journey of a car. The dots separate different sections of the journey. There are six different sections. How many sections represent the car when moving with non-uniform acceleration ? ..... .

ⓐ 0 ⓑ 1
ⓒ 2 ⓓ 3

28 The opposite (speed - time) graph represents a short journey. Which (distance - time) graph represents the same journey ? ..... .

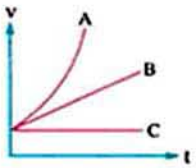




ⓐ ⓑ ⓒ ⓓ

Second Essay questions

1. The opposite graph represents the relation between the velocity (v) and the time (t) of three bodies A, B and C. Describe the motion of each body of them by choosing the best description from the following list : (constant velocity – uniform acceleration – non-uniform acceleration – static)



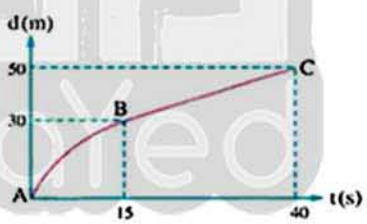
2. **Explain the following sentences :**
   (1) Acceleration is a vector quantity.
   (2) When an object moves at a uniform velocity, its acceleration equals zero.

3. If the acceleration of an object equals zero, does this mean that its velocity must equal zero ? Explain your answer.

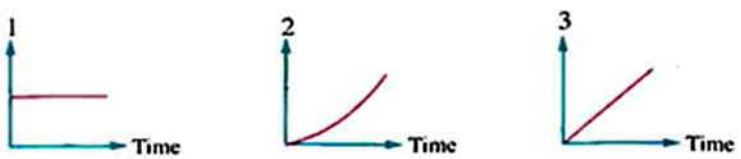
4. What happens when the driver presses the brakes of a moving car ? Concerning the value of its acceleration and the value of its final velocity.

5. Is it possible for the velocity of a car to be in the north direction when the car is affected at the same time by an acceleration in the south direction ? Discuss your answer.

6. The opposite graph shows the relation between the distance (d) and the time (t) of a body moving in a straight line :
   (a) Describe the motion of the body during the following intervals : 1- AB. 2- BC.
   (b) Mention the type of the acceleration (positive, negative or zero) in the following intervals :
   1- AB. 2- BC.

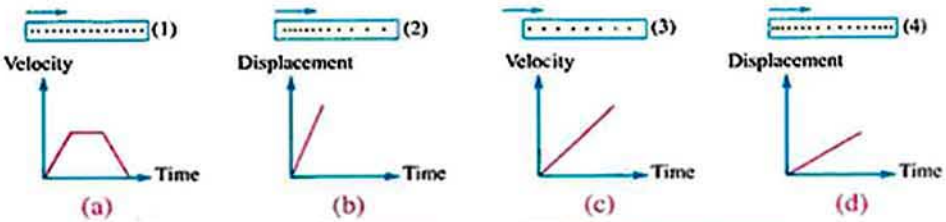


7. A bus is moving with uniform acceleration, where the following graphs represents the relation between the time on the horizontal axis and each of (1), (2) and (3) on the vertical axis :

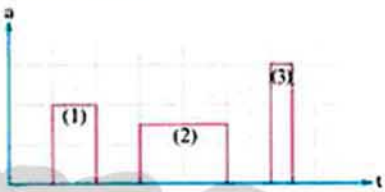


What are the physical quantities that are represented by the numbers (1), (2) and (3) ?

8 You have four ticker-tapes that describe the motion of objects. **Match** each ticker-tape with the proper graph that represents the same motion.



9 The opposite graph describes the motion of a body moving in a straight line through three time intervals. **Arrange** these intervals in descending order according to the velocity of the body.



10 Figure (1) represents the relation between the displacement (d) and the time (t) of a moving body :

(a) From figure (1) :

1- **Describe** the motion of the body from t = 0 to t = 2 s and calculate its velocity during this interval.

2- If the body moves with positive uniform acceleration from t = 2 s to t = 4 s, **add** on figure (1) the line that represents this motion.

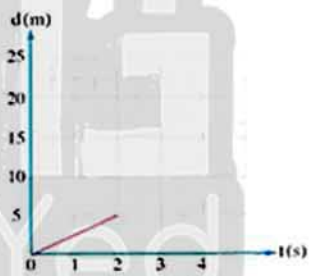


Figure (1)

(b) From figure (2) :

1- **Represent** the motion of the body from t = 0 to t = 2 s by using figure (1).

2- **Draw** what represents the motion of the body with uniform acceleration of 2 m/s^2 from t = 2 s to t = 4 s

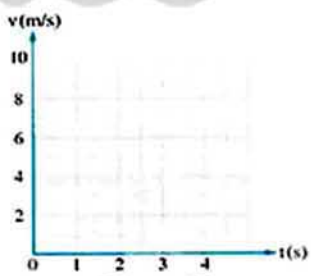
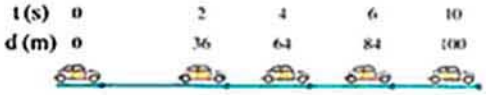


Figure (2)

Third Problems

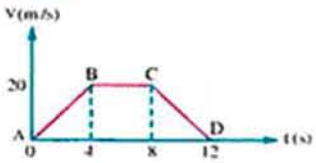
1 A car was moving at velocity 20 m/s. When its brakes were applied, it slowed down till stopped after a while as shown in figure. **Find :**



(a) The average velocity of the car.

(b) The acceleration of its motion and its type. (10 m/s, -2 m/s^2, uniform deceleration)

2 **Study the opposite graph and answer :**



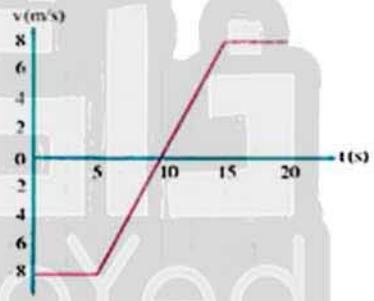
(a) **Describe** the motion during the 12 s.

(b) **Calculate** the acceleration of motion in each section.

(c) **Find** the distance covered by the object as it moves from A to D.

(uniform positive acceleration, uniform velocity, uniform deceleration, 5 m/s^2, zero, -5 m/s^2, 160 m)

3 The opposite graph shows the relation between the velocity and the time of a body moving in a straight line.
Plot the (acceleration - time) graph that represents the motion of this body.

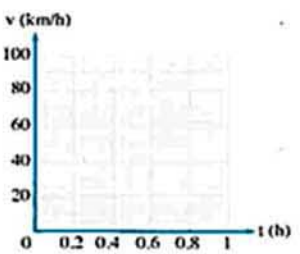


4 The opposite figure shows a speedometer of car that is moving in a straight line with a constant velocity :

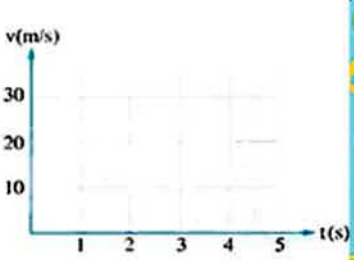
(a) **Calculate** the distance covered by the car during half an hour.

(b) **Draw** on the opposite graph paper a line that represents the motion of the car during the half hour mentioned in (a).

(c) After the first half an hour, the car reaches an inclined road that ascends to a mountain. The car climbs this road in half an hour and its velocity decreases during the climbing until it reaches 30 km/h. **Draw** a line on the same graph paper that represents the motion of the car during climbing the mountain (40 km). (40 km)



5 A runner is racing with a car, the runner moves with a constant velocity of 10 m/s while the car accelerates uniformly from 0 to 25 m/s. During the first five seconds of the race :



(a) **Draw** on the opposite graph paper a graph that represents the motion of both the runner and the car.

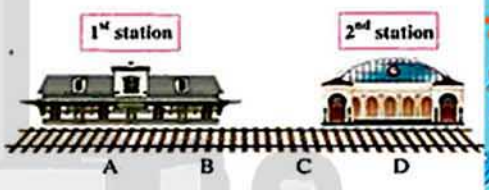
(b) **By using your drawing, calculate :**

1- The displacement covered by the runner during 5 s.

2- The displacement covered by the car during 5 s. (50 m, 62.5 m)

---

6 A train is moving in a straight line between two stations, where it starts its motion from rest at the first station and then it accelerates uniformly from point A to point B. After that the train moves with uniform velocity from point B to point C, then it decelerates uniformly from point C to point D (with the same rate between A and B) until it stops at the second station. If the distances AB, BC and CD are equal and the trip between the two stations takes 5 minutes, **calculate** the time taken by the train to cover each of the three distances AB, BC and CD. (120 s, 60 s, 120 s)



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7 The following table shows the recorded data for a moving object :

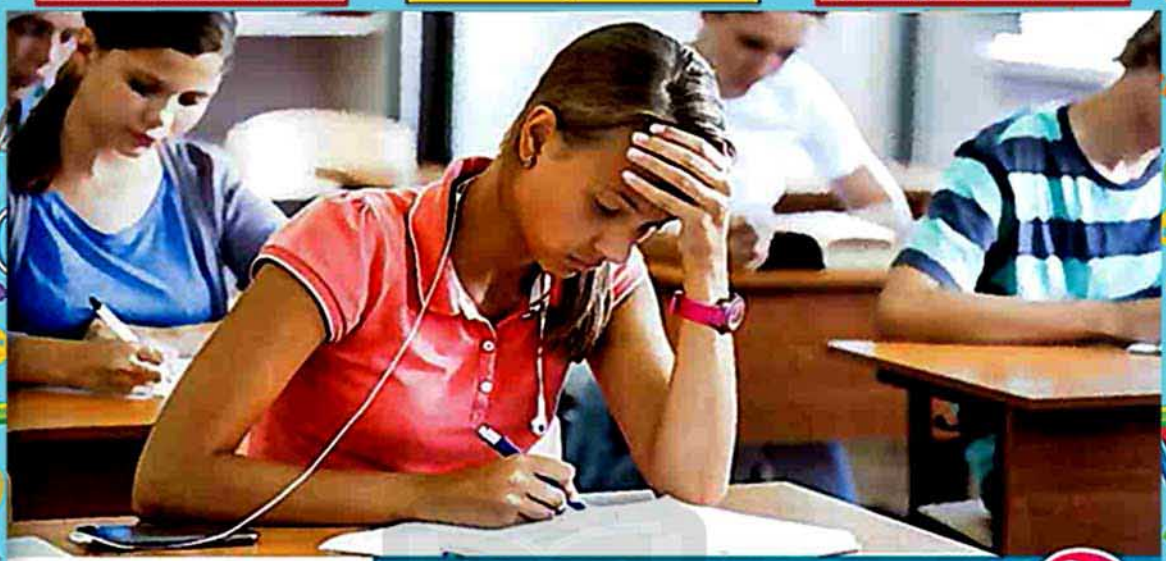
v (m/s)	10	20	30	40	b
t (s)	1	2	a	4	5

(a) **Plot** a graph between velocity (v) on the vertical axis and time (t) on the horizontal axis.

(b) **From the graph find :**

1- The values of a and b.

2- The acceleration of the object motion. (3 s, 50 m/s, 10 m/s^2)



MODEL EXAM ON

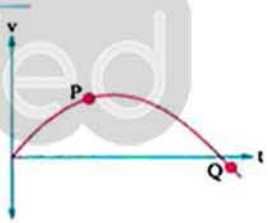
Chapter 1 Motion in a Straight Line

First Choose the correct answer

1. If a body starts its motion from rest and moves with uniform acceleration (a) in a straight line, then the average velocity ($\bar{v}$) of the body after time (t) equals ..... .

(a) at (b) 2 at (c) $\frac{at}{2}$ (d) $\frac{a}{t}$

2. The opposite (velocity - time) graph represents the motion of a car that is moving in a straight line, so the car at point Q moves ..... .



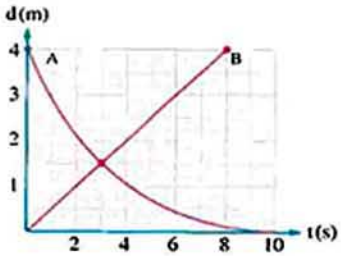
(a) with zero acceleration
(b) with decreasing velocity
(c) in a tunnel under the ground
(d) in a direction opposite to the direction of motion at point P

3. A car moves with initial velocity of 25 m/s to the north. If an acceleration of 3 m/s^2 to the south acts on it, then its velocity after 6 s will be ..... .

(a) 7 m/s to the north (b) 7 m/s to the south
(c) 20 m/s to the north (d) 20 m/s to the south

UNIT 2

4 The opposite graph represents the motion of two boys A and B, which of the following statements is right ? ..... .



(a) The average velocity of A is larger than the average velocity of B

(b) B moves with non-uniform velocity

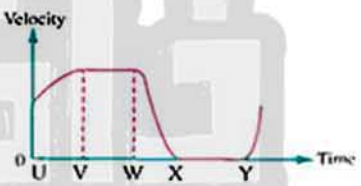
(c) A is moving away from the origin

(d) A and B meet at (t = 3 s)

5 A child is moving in a straight line as shown in the opposite figure. If the child takes 20 s to move from point Q to point R, then his average velocity equals ..... .

(a) 0.6 m/s (b) 0.5 m/s (c) 1.67 m/s (d) 2 m/s

6 The opposite (velocity - time) graph describes the motion of a car, so the time interval at which the car is at rest is ..... .



(a) UV (b) VW

(c) WX (d) XY

7 Which case of the following cases is impossible to happen ? ..... .

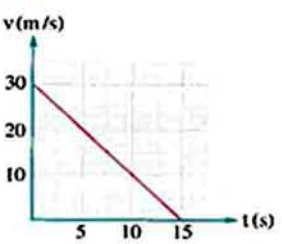
(a) A body is moving with a velocity to the east and its acceleration is in the west direction.

(b) A body is moving with a velocity to the east and its acceleration is in the east direction.

(c) A body is moving with non-uniform velocity and uniform acceleration.

(d) A body is moving with constant velocity and non-uniform acceleration.

8 The opposite graph represents the relation between the velocity of a body and the time. From the graph it is clear that the body moves with acceleration of ..... .



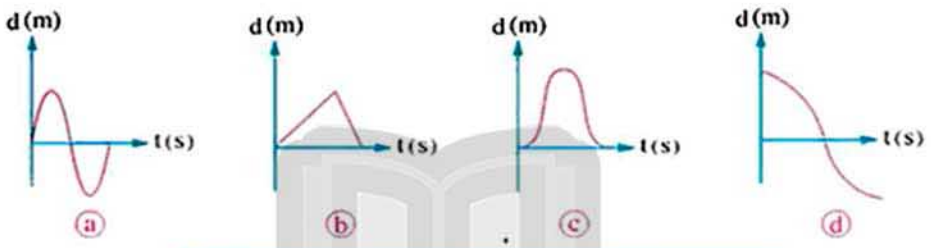
(a) + 10 m/s^2

(b) – 2 m/s^2

(c) + 5 m/s^2

(d) + 2 m/s^2

9 A car starts its motion from rest until it reaches velocity (v), then it decelerates until it comes to rest. After that it moves in the opposite direction until it returns to its starting point where its velocity changes by the same rate as in the first interval. Which of the following graphs represents the motion of the car ? ..... .



10 In the opposite figure, the train moves with velocity 40 m/s, it takes 2 seconds to pass the standing man, so the length of the train is ..... .

(a) 20 m (b) 38 m (c) 40 m (d) 80 m

Second Answer the following questions

11 When does the instantaneous velocity equalize with the average velocity of a moving body ?

12 The opposite ticker - tapes describe the motion of objects moving in a straight line towards the east. Draw the (velocity - time) graph for each ticker - tape and mention the type of the acceleration in each case.

(1) 

(2) 

13 A body starts its motion from rest and moves in a straight line with uniform acceleration to cover a distance of 100 m during 5 s. Calculate its acceleration.

.....

.....

14 What happens when a driver presses the brakes of a moving car ? Concerning the value of the car's acceleration and its final velocity.

.....

.....

15 If a body starts its motion from rest and moves with uniform acceleration, where its average velocity during 2 s is 3 m/s. **Calculate** its average velocity during 5 s.

.....

.....

.....

16 A body is moving in a straight line with uniform velocity (v) to cover a distance (d), then it moves with velocity (2 v) to cover a distance (2 d). **Calculate** its average velocity in terms of (v).

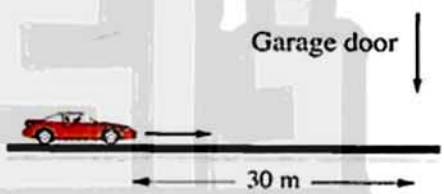
.....

.....

.....

.....

17 After stealing a car from a garage, the thief moved towards the garage's door trying to escape in a speed of 12 m/s. When he was 30 m away from the outlet, the security guard pressed a switch to close the door that started to fall down in a speed of 0.2 m/s from a height of 2 m. If the height of the car is 1.4 m, will he succeed to escape ?



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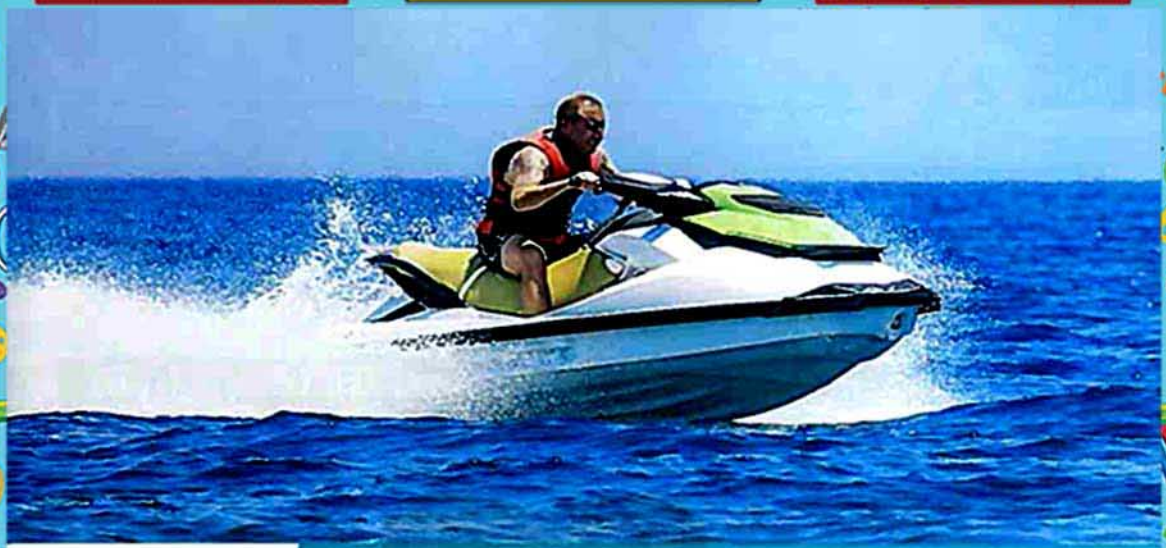


Chapter 2

LESSON ONE

Equations of Motion

- You have studied in the previous chapter that acceleration is the change of velocity per unit of time and acceleration could be uniform (constant) or non-uniform (changeable).
- Motion with uniform acceleration has a great importance since it represents the motion of a lot of objects in nature, such as :
  - Falling of objects near the Earth's surface.
  - Motion of projectiles.
- The motion of an object that starts its motion at initial velocity (v_i) in a straight line with a uniform acceleration (a) and reaches a final velocity (v_f) after a time interval (t) can be expressed by three equations which are called **the equations of motion**, they are :

First equation — The equation of (velocity - time)

The uniform acceleration (a) by which the body moves is given by the relation : $a = \frac{\Delta v}{\Delta t}$

- If the object starts motion at $t = 0$, then : $\Delta t = t - 0 = t$

$\because \Delta v = v_f - v_i$ $\quad\therefore a = \frac{v_f - v_i}{t}$

$\therefore at = v_f - v_i$ $\quad\therefore v_f = v_i + at$

The graphical representation for the first equation :

$$\text{Slope} = \frac{\Delta v}{\Delta t} = a$$

UNIT 2

Second equation — The equation of (displacement - time)

The average velocity of an object that covers displacement (d) in time (t) is given by the relation :

$$\bar{v} = \frac{d}{t} \qquad (1)$$

∵ The object moves at uniform acceleration, so the average velocity is also given by the relation :

$$\bar{v} = \frac{v_f + v_i}{2} \qquad (2)$$

From (1) and (2) :

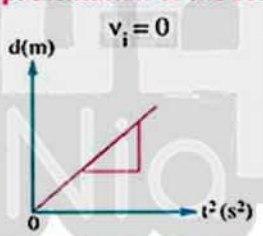
$$\therefore \frac{d}{t} = \frac{v_f + v_i}{2}$$

Substituting (v_f) from the first equation of motion ($v_f = v_i + at$) :

$$\therefore \frac{d}{t} = \frac{(v_i + at) + v_i}{2} = \frac{2v_i + at}{2} = v_i + \frac{1}{2}at$$

Multiplying both sides by (t) : ∴ $\mathbf{d = v_i t + \frac{1}{2} at^2}$

The graphical representation of the second equation :



$$\text{Slope} = \frac{\Delta d}{\Delta t^2} = \frac{1}{2}a$$

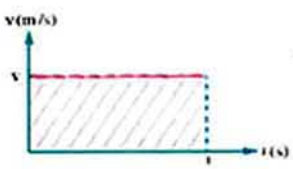
⊙ **Deriving the second equation of motion graphically :**

- In case of motion at **uniform velocity** which is represented by straight line parallel to the time axis.

∵ Displacement = Velocity × Time

∴ Displacement (numerically) = Length × Width

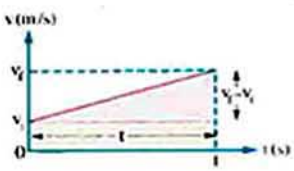
i.e. Displacement (numerically) = The area below the curve in the (velocity - time) graph



- In case of motion at **uniform acceleration**.

We can divide the area below the curve into :

- Area of a rectangle = Length × Width = $v_i t$
- Area of a triangle = $\frac{1}{2}$ (Base × Height) = $\frac{1}{2}(v_f - v_i)t$



$\because (v_f - v_i) = at$

$\therefore$ The area of the triangle $= \frac{1}{2} at^2$

By adding the two areas : $d = v_i t + \frac{1}{2} at^2$

Third equation — The equation of (displacement – velocity)

The displacement covered by a moving object is given by the relation :

$d = \bar{v}\, t$ ①

$\bar{v} = \frac{v_f + v_i}{2}$ ②

From the first equation of motion : $t = \frac{v_f - v_i}{a}$ ③

Substituting ② , ③ in equation ① :

$\therefore d = \bar{v}\, t = \frac{v_f + v_i}{2} \times \frac{v_f - v_i}{a}$

$\therefore d = \frac{v_f^2 - v_i^2}{2a}$

$\therefore \quad 2ad = v_f^2 - v_i^2$

The graphical representation for the third equation :

$$\text{Slope} = \frac{\Delta v^2}{\Delta d} = 2a$$

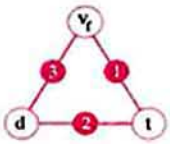
⊙ **The following table shows some special cases for the equations of motion :**

	The general formula	A body starts at rest ($v_i = 0$)	A body stops ($v_f = 0$)	A body moves with uniform velocity ($a = 0$)
1	$v_f = v_i + at$	$v_f = at$	$v_i = -at$	$v_f = v_i$
2	$d = v_i t + \frac{1}{2} at^2$	$d = \frac{1}{2} at^2$	$d = v_i t + \frac{1}{2} at^2$	$d = v_i t$
3	$2ad = v_f^2 - v_i^2$	$2ad = v_f^2$	$2ad = -v_i^2$	$v_f = v_i$

UNIT 2

Guidelines to solve problems

1. The opposite triangle would help in solving problems based on equations of motion where the number written between two (given and unknown) quantities indicates the order of the equation used to solve the problem.



2. Type of problems like : "an object moves according to a given relation " You should modify the given equation to be similar to one of the three equations of motion. Match them to find the required answer.

Example 1

Find the time taken by an aeroplane till it stops if it lands on the runway at velocity of 162 km/h and decelerates uniformly at 0.5 m/s².

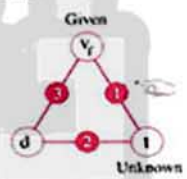
Solution

$v_i = 162 \text{ km/h} = 162 \times \frac{5}{18} = 45 \text{ m/s}$ $\quad v_f = 0$ $\quad a = -0.5 \text{ m/s}^2$ $\quad t = ?$

From the first equation of motion : $v_f = v_i + at$

$0 = 45 + (-0.5)\, t$

$t = \frac{-45}{-0.5} = 90 \text{ s}$



Example 2

An object moves with uniform acceleration according to the relation : $d = 14\,t + 10\,t^2$

Find :

(a) The initial velocity and the acceleration of the object's motion.

(b) The distance moved by the object after 5 s.

Solution

Clue

Match the given equation by the similar equation from the three equations of motion.

(a) The second equation of motion : $d = v_i\, t + \frac{1}{2} a\, t^2$ ①

$d = 14\, t + 10\, t^2$ ②

From equations ① and ② :

$\because v_i\, t = 14\, t$ $\quad \therefore v_i = 14 \text{ m/s}$

$\because \frac{1}{2} a t^2 = 10\, t^2$ $\quad \therefore a = 20 \text{ m/s}^2$

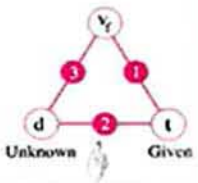
(b) $t = 5$ s | $a = 20$ m/s^2 | $v_i = 14$ m/s | $d = ?$

From second equation of motion :

$$d = v_i t + \frac{1}{2} at^2$$

$$= (14 \times 5) + (\frac{1}{2} \times 20 \times 25)$$

$$= 70 + 250 = 320 \text{ m}$$



Example 3

A man drove a car at uniform velocity of 30 m/s. Suddenly, he saw a child crossing the street and he applied the brakes to decelerate the car uniformly at 9 m/s^2 till it stopped. If the reaction time of the driver till he pressed the brakes is 0.5 s. Find the displacement of the car from the moment of seeing the child till stopping the car.

Solution

$v_i = 30$ m/s | $t_{reaction} = 0.5$ s | $a = -9$ m/s^2 | $v_f = 0$ | $d_{total} = ?$

Clue

When the driver saw the child he applies the brakes after 0.5 s and during this time the car covers displacement d_1 and when the driver applies the brakes, the car decelerates uniformly till it stops after covering displacement d_2. So, the total displacement covered by the car (d) is : $d = d_1 + d_2$

- Displacement of the car during the reaction time till using the brakes (uniform velocity) :

$$d_1 = v_i \cdot t_{reaction} = 30 \times 0.5 = 15 \text{ m}$$

- Displacement of the car when applying the brakes (uniform deceleration) :

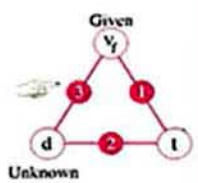
From the third equation of motion :

$$2ad = v_f^2 - v_i^2$$

$$\therefore 2ad_2 = -v_i^2$$

$$d_2 = \frac{-v_i^2}{2a} = \frac{-(30)^2}{2 \times (-9)} = 50 \text{ m}$$

$$\therefore d = 15 + 50 = 65 \text{ m}$$



Example 4

A body moves with initial velocity of 20 m/s in the east direction. If it is affected by an acceleration of 4 m/s^2 in the west direction, calculate the magnitude and the direction of its velocity after 10 s.

Solution

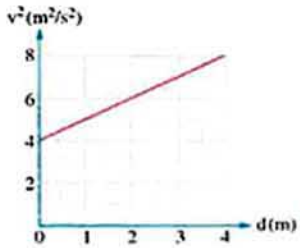
$v_i = 20$ m/s $a = -4$ m/s^2 $t = 10$ s $v_f = ?$

$v_f = v_i + at = 20 + (-4 \times 10) = -20$ m/s

$\therefore$ The body moves with velocity of 20 m/s in the west direction.

Example 5

The opposite graph describes the motion of a body that moves by uniform acceleration. Calculate the time taken by the body to reach a velocity of 16 m/s.



Solution

$\because v_i^2 = 4$, $\therefore v_i = 2$ m/s

$\because v_f^2 - v_i^2 = 2\,a\,\Delta d$, $\because$ Slope $= \frac{\Delta v^2}{\Delta d} = \frac{8-4}{4-0} = 1$

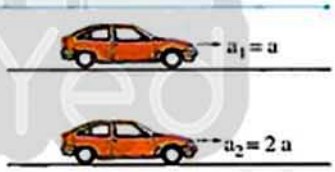
$\therefore$ Slope $= 2a = 1$ $\therefore a = 0.5$ m/s^2

From the first equation of motion : $v_f = v_i + at$

$16 = 2 + 0.5\,t$, $\therefore t = 28$ s

Example 6

Two cars start their motion from rest from the same position in the same direction as in the opposite figure, after 10 s the distance between them becomes 200 m, calculate the value of a.



Solution

Clue

The first car covers displacement d_1 after time $t = 10$ s and the second car covers displacement d_2 after the same time and the difference between the displacements of the two cars at this time is 200 m.

$\because d = v_i t + \frac{1}{2} a t^2$, $v_i = 0$

$\therefore d_1 = \frac{1}{2} a t^2$, $d_2 = a t^2$

$\because d_2 - d_1 = 200$ $\therefore a t^2 - \frac{1}{2} a t^2 = 200$

$\therefore \frac{1}{2} a t^2 = 200$, $\because t = 10$ s

$\therefore \frac{1}{2} a (10)^2 = 200$, $\therefore a = 4$ m/s^2

Life application (safety skills)

⊙ **To avoid the dangers of exceeding prescribed speeds and to save souls, traffic instructions should be followed such as :**

- Leaving an appropriate distance between vehicles to allow the driver to stop safely in case of emergency and more spacing between vehicles is required when :
- Speed of cars gets higher.
- The road is wet or has oil stains.
- Vehicles are huge such that trucks should leave larger spacing than small cars.

Test yourself

1. **Choose :** A car moves in a straight line with initial velocity of 20 m/s towards the north. If it moves with an acceleration of 2 m/s^2 towards the south, then its velocity after 12 s equals .....

(a) 4 m/s to the north (b) 4 m/s to the south

(c) 20 m/s to the north (d) 20 m/s to the south

2. **Prove that :** If a body moves with uniform velocity v_i then it is affected by a negative acceleration till it stops, its displacement is given by the relation : $d = \frac{1}{2} at^2$

.....

.....

.....

.....

3. If the velocity of a ship that moves in a straight line increases from 20 m/s to 30 m/s after covering a displacement of 200 m, **calculate** the time taken by the ship to cover this displacement.

.....

.....

.....

.....

QUESTIONS ON
Chapter 2
LESSON ONE

Equations of Motion

Interactive test

First Multiple choice questions

1. If the displacement of a body moving with uniform acceleration is given by the relation : $d = v_i t + \frac{1}{2} at^2$, the initial velocity of the body $v_i = 10$ m/s and it is moving with acceleration $a = 2$ m/s^2, then its displacement after 10 s is .....

(a) 100 m (b) 200 m (c) 300 m (d) 400 m

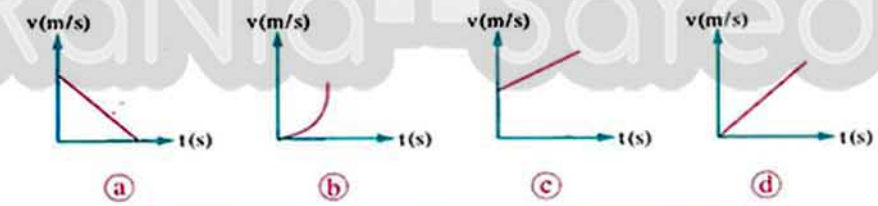
2. The final velocity of a body moving with uniform acceleration is given by the relation : $v_f = \sqrt{v_i^2 + 2ad}$. If the initial velocity of the body is 6 m/s and it moves by acceleration 4 m/s^2, then its velocity is ..... after it covers a displacement of 8 m.

(a) 5 m/s (b) 10 m/s (c) 15 m/s (d) 20 m/s

3. If an object starts motion from rest and takes time (t) which is numerically equal to the magnitude of its uniform acceleration (a) to reach a final velocity of 16 m/s, the magnitude of its uniform acceleration = ...

(a) 2 m/s^2 (b) 4 m/s^2 (c) 8 m/s^2 (d) 16 m/s^2

4. The graph labeled ..... represents the motion of an object that has initial velocity (v_i) and speeds up at uniform acceleration (a) during time (t).



(a) (b) (c) (d)

5. A motorcyclist started motion from rest at a uniform acceleration of 1.5 m/s^2. Its velocity has reached 7.5 m/s through a displacement of .....

(a) 11.25 m (b) 18.75 m (c) 187.5 m (d) 1875 m

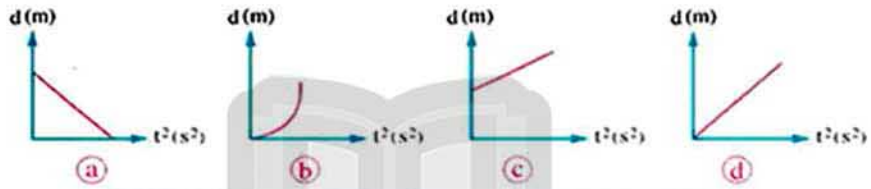
6. A body starts its motion from rest and moves with constant acceleration. If its average velocity during 8 s is 1.5 m/s, so its instantaneous velocity is ..... after 30 s from starting its motion.

(a) 15.4 m/s (b) 12.5 m/s (c) 11.25 m/s (d) 9.25 m/s

7 A body starts its motion from rest and moves with uniform acceleration. If its average velocity is 10 m/s when it covers a displacement of 20 m, then its average velocity during 8 s is .....

(a) 2 m/s (b) 40 m/s (c) 10 m/s (d) 80 m/s

8 The graph labeled ..... represents the motion of an object at zero initial velocity and speeds up uniformly.

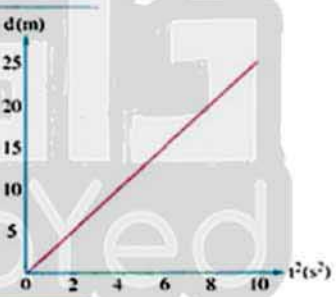


9 If a body starts its motion from rest and moves in a straight line with acceleration of 5 m/s^2, then .....

(a) the slope of the (d – t) graph is 5
(b) the slope of the (v^2 – t) graph is 5
(c) the slope of the (d – t^2) graph is 2.5
(d) the slope of the (v – t) graph is 2.5

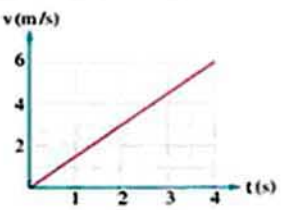
10 The opposite graph represents the motion of a body moving with a uniform acceleration, then its velocity after 10 s is .....

(a) 25 m/s
(b) 50 m/s
(c) 100 m/s
(d) 2.5 m/s



11 The opposite graph describes the motion of a car moving with uniform acceleration, so its velocity after 100 m is .....

(a) 10 m/s
(b) $10\sqrt{3}$ m/s
(c) $10\sqrt{2}$ m/s
(d) 20 m/s



12 Two bodies start their motion from rest and move in a straight line with uniform acceleration to cover a distance d. If the time taken by the first body to cover this distance is double the time taken by the second body, then the ratio between the acceleration of the first body and the acceleration of the second body is .....

(a) $\frac{1}{1}$ (b) $\frac{1}{2}$ (c) $\frac{1}{4}$ (d) $\frac{1}{16}$

13 A body starts its motion from rest and moves with uniform acceleration to cover a displacement (d) during time (t), so it covers a displacement ..... in time (2t).

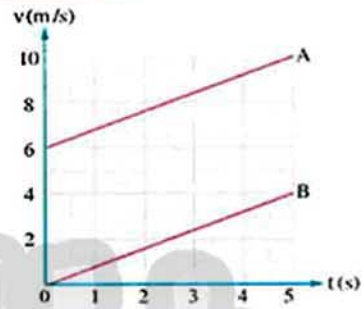
(a) d (b) 2 d (c) 4 d (d) $\sqrt{2}$ d

14 Car accelerates uniformly from rest to reach velocity (v) and covers distance (d), the velocity of the car when it covers distance (2d) is .....

(a) v (b) $\sqrt{2}$ v (c) 2 v (d) 4 v

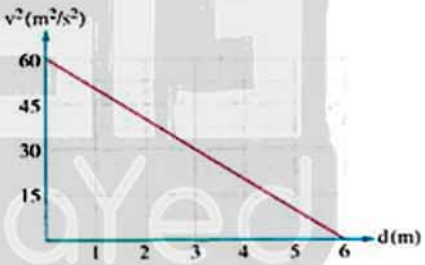
15 The opposite graph represents the relation between the velocities of two bodies A and B and the time, so the difference between their displacements is .....

(a) 10 m
(b) 50 m
(c) 30 m
(d) 60 m



16 The opposite graph describes the motion of a body with a uniform acceleration. What is the acceleration and the time of motion of this body ? .....

(a) – 5 m/s^2 , 1.55 s
(b) – 3.33 m/s^2 , $\sqrt{2}$ s
(c) – 5 m/s^2 , 5.01 s
(d) $\sqrt{5}$ m/s^2 , $\sqrt{3}$ s



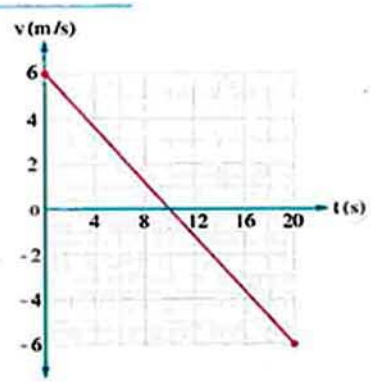
17 The opposite graph represents the relation between the velocity of a body and the time during 20 s, so :

(i) The total displacement covered by the body is ..... .

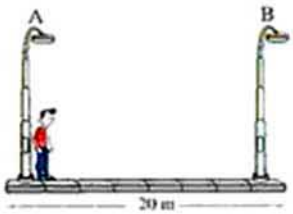
(a) 20 m (b) 12 m
(c) 60 m (d) 0

(ii) The total distance covered by the body is .....

(a) 20 m (b) 12 m
(c) 60 m (d) 0



18 The man in the opposite figure starts his motion from rest with an acceleration of 0.5 m/s^2 at the light pole A till his velocity reaches 2 m/s, then he moves uniformly by this velocity until he reaches the light pole B. So the total time of the man's motion is .....



(a) 4 s (b) 8 s
(c) 12 s (d) 16 s

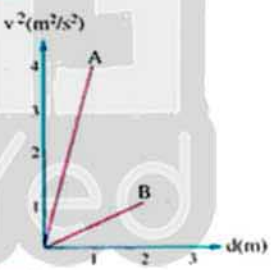
19 A body is moving according to this relation : $t = \sqrt{\frac{2d}{3}}$, so the velocity of the body after 4 s is .....

(a) $\frac{2}{3}$ m/s (b) 3 m/s (c) 4 m/s (d) 12 m/s

20 A train of length 100 m enters a straight tunnel of length 1 km with a velocity of 4 m/s. If the train is moving by acceleration 0.5 m/s^2, then the required time for the entire train to leave the tunnel is .....

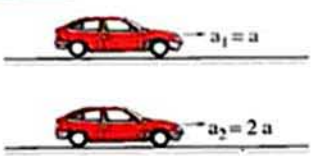
(a) 550 s (b) 58.81 s (c) 20.31 s (d) 20 s

21 In the opposite figure : Two bodies A and B start their motion from rest, so the ratio between the final velocities of A and B respectively after passing 5 s is .....



(a) $\frac{8}{1}$ (b) $\frac{4}{1}$
(c) $\frac{1}{8}$ (d) $\frac{1}{4}$

22 If two cars starts their motion from rest at the same starting point and move in the same direction as in the opposite figure, the distance between them was 200 m after time (t) , then the distance between them after time (2 t) is .....

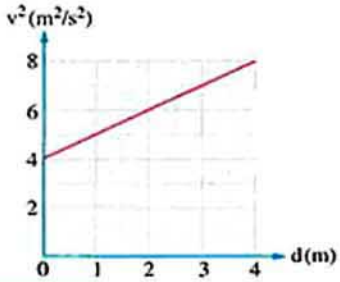


(a) 200 m (b) 400 m (c) 800 m (d) 1600 m

23 A police officer finds 60 m of skid marks at the scene of a car crash. Assuming a uniform deceleration of 7.5 m/s^2 to a stop, what was the velocity of the car when it started skidding ? .....

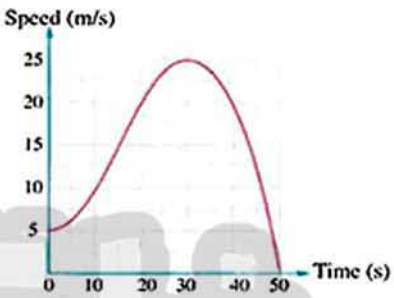
(a) 20 m/s (b) 30 m/s (c) 45 m/s (d) 60 m/s

24 The opposite graph describes the motion of a body moving by a uniform acceleration, so the acceleration of this body equals .....



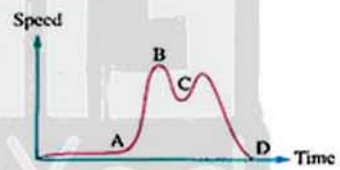
(a) 8 m/s^2 (b) 4 m/s^2
(c) 0.5 m/s^2 (d) 1 m/s^2

25 The opposite (speed - time) graph describes the motion of a car. What is the acceleration of the car at 30 s ? .....



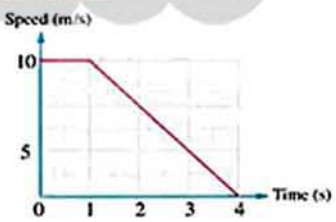
(a) 0
(b) $\frac{25-5}{30}$ m/s^2
(c) $\frac{25}{30}$ m/s^2
(d) $\frac{25}{50}$ m/s^2

26 A cyclist travels along a hilly road without using the pedals or brakes. Air resistance and friction are negligible. The (speed - time) graph of the cyclist is shown. At which point did he reach the bottom of the first hill ? .....



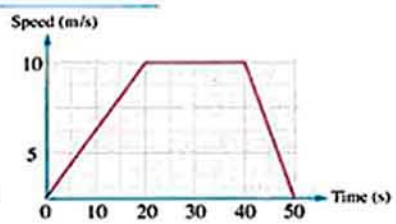
(a) A (b) B (c) C (d) D

27 The diagram shows the (speed - time) graph of the motion of a car for four seconds. What is the distance travelled by the car in the four seconds ? .....



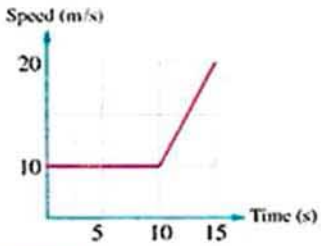
(a) 15 m (b) 25 m
(c) 30 m (d) 4 m

28 The graph shows the movement of a car over a period of 50 s. What was the distance travelled by the car while its speed was increasing ? .....



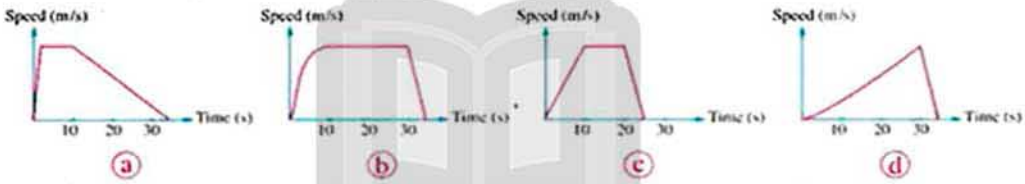
(a) 10 m (b) 20 m
(c) 100 m (d) 200 m

29 An object travels at a constant speed of 10 m/s for 10 s. During the next 5 s, it accelerates uniformly to 20 m/s. What is the total distance travelled by the object ? .....

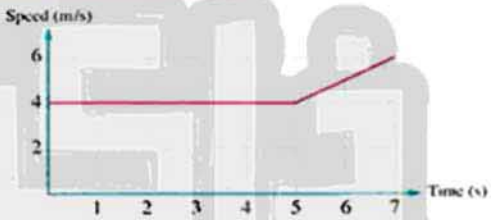


(a) 150 m (b) 175 m
(c) 200 m (d) 300 m

30 A car accelerates from traffic lights for 10 s. It stays at a steady speed for 20 s and then brakes to a stop in 3 s. Which graph shows the journey ? .....



31 The graph shows part of a journey made by a cyclist. How far did the cyclist travel in 7 s ? .....



(a) 28 m (b) 30 m
(c) 32 m (d) 42 m

Second Essay questions

1 **Can we apply the equations of motion when :**

(a) The acceleration of a body changes with time.

(b) The acceleration of a body equals zero.

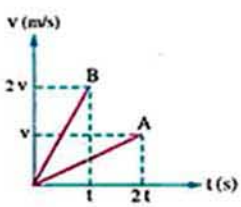
Explain your answer.

2 If the distance covered by a body during time (t) is given by the relation :

$d = \frac{1}{2} at^2$, where (a) is the acceleration of the body.

Mention three conditions that makes the previous relation applicable.

3 The opposite diagram illustrates two objects that started their motion from rest.

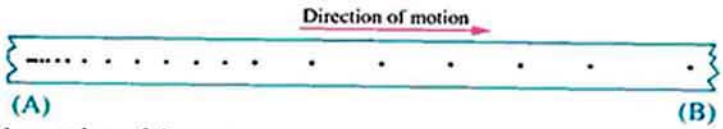


(a) **Which** object has moved at a greater acceleration? **And why?**

(b) **Which** object has covered a greater distance? **And why?**

UNIT 2

4 A student carried out an experiment to study the motion of a cart that started from rest using a ticker-timer where the position of the cart is determined every second on ticker-tape as shown in figure :

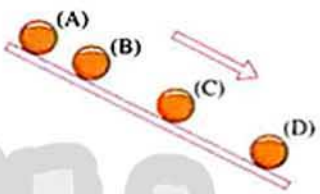


(a) **Describe** the motion of the cart.

(b) **Find** the average velocity if the displacement covered from (A) to (B) is 190 m.

(c) **Find** the acceleration of the cart.

5 This figure illustrates a ball rolling down a smooth plane at a uniform acceleration. Points (A, B, C and D) indicate the ball position every 0.5 s. **Based on the figure, answer the following :**



(a) **How can** you detect that the ball is speeding up?

(b) **Why does** velocity increase?

(c) **Calculate** the ball acceleration if the distance between (A) and (D) = 2 m

6 An object starts its motion from the position (x_i) with an initial velocity (v_i) and moves in a straight line with uniform acceleration. **Prove that** its final position (x_f) can be determined from the relation :

$$x_f = x_i + \frac{1}{2}(v_i + v_f)\,t$$

7 From the first and the second equations of motion **prove that :** $d = v_f t - \frac{1}{2} a t^2$

8 **Explain why the following situation is impossible :**
"A body starts its motion from rest and moves in a straight line with uniform acceleration to cover a distance of 50 m in 10 s where its final velocity after this time is 8 m/s".

Third Problems

1 A plane landed on the runway at velocity of 50 m/s and then decelerates uniformly at 2 m/s^2, **calculate** the time taken by the plane to stop completely. (25 s)

2 A body moves in a straight line with uniform acceleration of – 4 m/s^2, if its velocity at 10 : 05 : 00 am was 13 m/s, **calculate** its velocity at :

(a) 10 : 04 : 59 am (b) 10 : 05 : 01 am (c) 10 : 05 : 04 am (17 m/s, 9 m/s, – 3 m/s)

3. An object has started motion from rest at uniform acceleration of 2 m/s^2 for 10 s. **Calculate :**
   (a) Its final velocity.
   (b) The distance moved. (20 m/s, 100 m)

4. A bullet moved in a horizontal path at velocity of 100 m/s. This bullet penetrated a fixed target to 10 m deep before stopping. **Find** the acceleration of the bullet inside the target assuming that it is a uniform acceleration. ($-500\ m/s^2$)

5. An electron in the cathode ray tube is accelerated uniformly from 2×10^4 m/s to 6×10^6 m/s through a distance of 1.5 cm, **calculate** the time taken by the electron to cover this distance. (4.98×10^{-9} s)

6. A car was moving at 20 m/s. When the brakes were applied, it decelerated uniformly at 2 m/s^2. **Calculate :**
   (a) The time taken to stop. (b) The distance moved during braking.
   (c) The average velocity during this interval. (10 s, 100 m, 10 m/s)

7. A body was moving at initial velocity 40 m/s and decelerated uniformly at 4 m/s^2. **Calculate** the distance covered by the body in 5 s and the time required to stop. (150 m, 10 s)

8. A train is moving with a velocity of 72 km/h, if it decelerates with 2 m/s^2, what is the required time for the train to reach a velocity of 13 km/h ? (8.2 s)

9. A body was moving at uniform velocity of 4 m/s for 8 s and then at uniform acceleration of 4 m/s^2 for 6 s. **Calculate** the total distance moved by the body. (128 m)

10. A car is moving with velocity of 56 km/h and the minimum distance that would be taken by the car to stop is 12 m. **Calculate** by two different methods the minimum distance that would be taken by the car to stop, if the car is moving with velocity of 113 km/h. (Assume that the acceleration is constant in both cases) (48.9 m)

11. A driver saw the red traffic light when he was moving with 80 km/h at 100 m away from the car, he used the brakes to decelerate at 2 m/s^2.
   (a) **Would** the car cross the traffic sign?
   (b) **Calculate** the time taken by the car to stop. (Yes, 11.11 s)

12 A man was driving in a straight road where he suddenly saw a falling tree that closes the road, so he applied the brakes to slow down the car by uniform acceleration of 5.6 m/s^2 never the less he hit the tree after 4.2 s. If the tree was 62.4 m away from the car when the brakes were applied, **calculate** the velocity by which the car collides with the tree.

(3.1 m/s)

13 A vehicle has started motion from rest at uniform acceleration of 2 m/s^2 during 6 s and then moved at uniform velocity for half a minute. Next to that, the brakes are applied to decelerate the vehicle to stop within 5 s. **Calculate :**

(a) The greatest velocity reached by the vehicle.

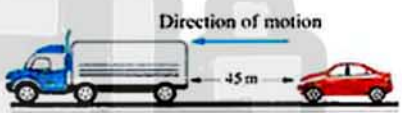
(b) The total distance moved by the vehicle.

Then, plot the (velocity - time) graph of the vehicle's motion. (12 m/s, 426 m)

14 A car moves with velocity of 30 m/s and after 5 s its velocity becomes 10 m/s. **Calculate** the distance covered by the car in the third second. (20 m)

15 The opposite figure shows a car moving with uniform velocity of 60 km/h, the car's driver suddenly saw a break down truck which is 45 m apart from him so the driver applies the brakes to decelerate the car by 2.77 m/s per second.

Prove mathematically that the car will collide with the truck.



16 A car has started motion from rest at uniform acceleration of 2 m/s^2. After moving a distance of 100 m, the driver turned the engine off, so the car stopped 5 s afterwards. **Find** the acceleration and the distance moved during these 5 seconds. (- 4 m/s^2, 50 m)

17 Two cars A and B start their motion from rest from the same point. If car A moves with acceleration (a) and car B moves with acceleration (1.5 a) and after 50 s the velocity of car B becomes larger than the velocity of car A by 50 m/s, **calculate :**

(a) The value of acceleration (a).

(b) The difference between the distances that are covered by the two cars A and B.

(2 m/s^2, 1250 m)

18 An object is moving according to the relation : $d = 16\,t - 1.5\,t^2$

Find :

(a) The initial velocity of the object.

(b) The acceleration of the object motion.

(c) The time required by the object to stop when it decelerates by the same value.

(d) The object velocity after moving 4 m. (16 m/s, -3 m/s^2, 5.3 s, 15.2 m/s)

19 An object is moving according to the relation : $t = \frac{1}{2} v_f - 6$

Find :

(a) The initial velocity of the object.

(b) The acceleration of the object motion.

(c) The distance covered by the object in 10 s. (12 m/s, 2 m/s^2, 220 m)

20 An object moves according to the relation : $v_f = \sqrt{36 + 5d}$, **find :**

(a) The initial velocity of the object.

(b) The acceleration of the object motion.

(c) The displacement of object after 20 s.

(d) The displacement of object when its velocity reaches 20 m/s.

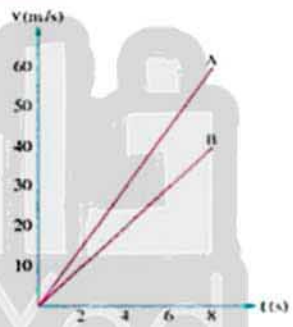
(e) The velocity of the object after 15 s. (6 m/s, 2.5 m/s^2, 620 m, 72.8 m, 43.5 m/s)

21 The opposite graph represents the relation between velocity and time for two objects (A) and (B) moving from rest.

Calculate :

(a) The displacement of each object after 6 s.

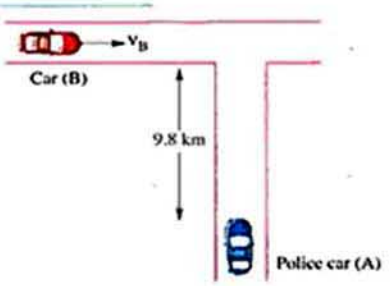
(b) The time taken by the object (B) to be displaced through the same displacement of the object (A) after 6 s.



(135 m , 90 m, 7.35 s)

22 A tiger started running when it saw a deer running at uniform velocity of 2 m/s at 15 m far from it. If the tiger ran at acceleration of 2 m/s^2. **When** and where will the tiger catch the deer ? (5 s, 25 m from starting motion)

23 In the opposite figure : A static police car (A) which is at a distance of 9.8 km from the highway received a report about a moving car (B) at 40 m/s on this way. If the maximum acceleration of the police car is 4 m/s, **at what** distance should be car (B) if the policeman wants to reach before it by 30 s?



(4 km)

24 The table below shows the relation between displacement and time :

d (m)	0	10	40	90
t (s)	0	2	4	6

(a) **Plot** the graphical relation between the displacement (d) on y-axis and square of the time (t^2) on x-axis.

(b) **From the graph find** the acceleration of the object. ($5\ m/s^2$)

25 The table below shows the relation between the distance moved by an object in a straight line at uniform acceleration and time (the object starts motion from rest) :

d (m)	0	3	12	27	48	75
t (s)	0	1	2	3	4	5

(a) **Find** the acceleration of the motion of the object.

(b) **Plot** the graphical relation between velocity and time.

(c) **From** the graph find the object velocity after 1.5 s. ($6\ m/s^2$, $9\ m/s$)

Chapter 2

LESSON TWO

Applications of Motion with Uniform Acceleration (Free Fall - Vertical Projectiles)

⊙ In the previous lesson we talked about the equations of motion that describe the motion of objects at uniform acceleration and as follows we will study some applications of motion with uniform acceleration, such as :

First : Free fall

Falling of a parachutist

Second : Projectiles

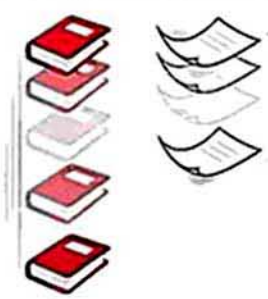
Shooting a flare

First Free fall

⊙ If two objects of different masses (a book and a sheet of paper) are dropped at the same time from the same height, the two objects start motion from rest ($v_i = 0$) falling under the effect of two forces :

1. The gravitational pull of the Earth (their weights).
2. The air resistance.

Since collision of the object with air molecules affects the velocity of falling of light objects (the paper sheet) more than that of heavier objects (the book), we find that the book reaches the ground first.



UNIT 2

- If the air resistance is neglected, the two objects fall under the effect of their weights only and acquire a uniform acceleration that acts to increase the speed of falling gradually till it reaches its maximum value when touching the ground. This acceleration is called **acceleration due to gravity (free fall acceleration)** which is the uniform acceleration by which objects move during free fall towards the ground.
- The free fall acceleration varies slightly from one position to another on the Earth's surface because the Earth's shape is not completely spherical but it is elliptical, where its equatorial diameter is bigger than its polar diameter, so the free fall acceleration varies depending on the distance from the Earth's center.
- The average value of free fall acceleration equals $9.8\ m/s^2$ and for simplicity it can be considered $10\ m/s^2$.

Distinguished Scientists

Galileo

Galileo proved that :

Falling objects of different masses, when neglecting air resistance , reach the ground at the same time.

He put an end for Aristotle's idea that implied : "Heavy objects would reach the ground in a shorter time than that taken by lighter objects".

He proved this by dropping two objects of different masses down Tower of Pisa in Italy.

Notes :

1. When objects move under the effect of gravity we can apply the equations of motion as follows :

$$v_f = v_i + gt \quad , \quad d = v_i t + \frac{1}{2}gt^2 \quad , \quad 2gd = v_f^2 - v_i^2$$

2. When an object falls freely downwards :

- The velocity of the object increases gradually till it reaches its maximum value when **reaching the ground.**

Its initial velocity $v_i = 0$

$$\therefore \quad g = \frac{\Delta v}{\Delta t} = \frac{v_f - v_i}{t - 0} = \frac{v_f}{t}$$

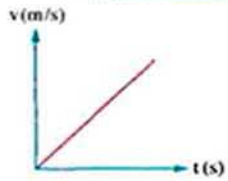
3. When an object is projected vertically upwards :

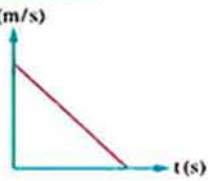
- The velocity of the object decreases gradually till it vanishes at the **maximum height.**

Its final velocity $v_f = 0$

$$\therefore \quad g = \frac{\Delta v}{\Delta t} = \frac{v_f - v_i}{t - 0} = \frac{-v_i}{t}$$

That can be represented graphically as follows :





- The free fall acceleration (g) has a positive sign (increasing velocity) since the direction of object motion is in the same direction of Earth's gravity.
- The free fall acceleration (g) has a negative sign (decreasing velocity) since the direction of object motion opposes the direction of Earth's gravity.

4. The next table shows the instantaneous velocity of a body that falls freely every second, we notice that the instantaneous velocity of the body after one second is 10 m/s but that doesn't mean that the body falls a distance of 10 m during the first second, because the body moves with acceleration (free fall acceleration) so its instantaneous velocity differs from its average velocity and we find from the second equation of motion ($d = v_i t + \frac{1}{2} gt^2$) that the body falls a distance of 5 m and after two seconds it falls a distance of 20 m as in the following table :

The instantaneous velocity (m/s)	The falling distance (m)	The time taken (s)
0	0	0
10	5	1
20	20	2
30	45	3
40	80	4
50	125	5
gt	$\frac{1}{2}gt^2$	t

Example 1

A stone fell from the roof of a building. If the stone passed by a man standing in a balcony 5 m high above the ground 2 s later (consider : $g = 10\ m/s^2$), find :

(a) The building height.

(b) The stone velocity at the moment of passing by the man.

Solution

$v_i = 0$ | $d_1 = 5$ m | $g = 10$ m/s^2 | $t = 2$ s | $h = ?$ | $v_f = ?$

Clue

The height of the building is the distance covered by the stone from the roof of the building to the balcony (d_2) added to the distance covered by the stone from the balcony to the ground (d_1).

(a) $d_2 = v_i t + \frac{1}{2} g t^2$

$= 0 + (\frac{1}{2} \times 10 \times 2^2) = 20$ m

$h = d_1 + d_2 = 5 + 20 = 25$ m

(b) The stone velocity when it passes in front of the man : $v_f = v_i + gt$

$v_f = 0 + (10 \times 2) = 20$ m/s

Example 2

An apple has fallen freely from a tree and reached the ground after 1 second. Find :

(a) Its velocity at the moment of hitting the ground.

(b) The average velocity of the apple during falling.

(c) The height from which it fell. ($g = 10$ m/s^2)

Solution

$v_i = 0$ | $g = 10$ m/s^2 | $t = 1$ s | $v_f = ?$ | $\bar{v} = ?$ | $d = ?$

(a) Velocity at reaching the ground : $v_f = v_i + g t$

$v_f = 0 + (10 \times 1) = 10$ m/s

(b) The average velocity : $\bar{v} = \frac{v_f + v_i}{2} = \frac{10 + 0}{2} = 5$ m/s

(c) The height from which the apple fell : $d = v_i t + \frac{1}{2} g t^2$

$d = 0 + \frac{1}{2} \times 10 \times 1^2 = 5$ m

Example 3

The following table records the values of velocity, displacement and time of a free falling object :

Time (s)	Displacement (m)	Velocity (m/s)
0	0	0
0.5	1.25	5
1	5	10
1.5	11.25	15
2	20	20

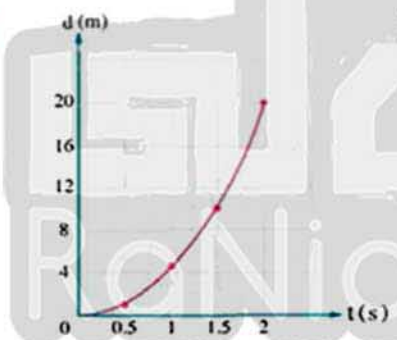
(a) Use the recorded data to plot the graphical relationships of (displacement - time) and (velocity - time) that describe the motion of the object.

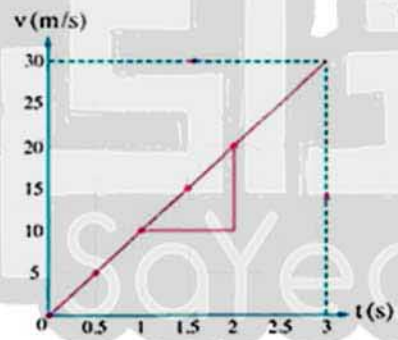
(b) What can be concluded from the increase in spacing between the object positions with passing equal intervals of time ?

(c) Calculate the displacement and the velocity of the object after 3 s from the instant of falling.

Solution

(a)





(b) The increase in spacing between the object positions with time indicates that the object moves at increasing velocity (positive acceleration).

(c) To find the acceleration (a) of the object's motion, we evaluate the slope of the straight line in (velocity - time) graph.

$$a = \frac{\Delta v}{\Delta t} = \frac{20 - 10}{2 - 1} = 10 \text{ m/s}^2$$

$$d = v_i t + \frac{1}{2} g t^2$$

$$= 0 + \frac{1}{2} \times 10 \times (3)^2 = 45 \text{ m}$$

$$v_f = v_i + g t = 0 + (10 \times 3) = 30 \text{ m/s}$$

UNIT 2

Practical Experiment

Determination of the acceleration due to gravity using water drops.

1. Experiment Objective :

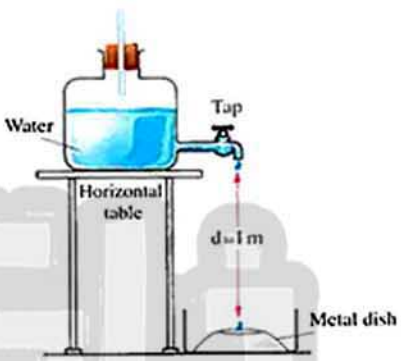
Determining the acceleration due to gravity (g).

2. Experiment Idea :

- Measuring the time (t) taken by a water drop to fall freely through a vertical displacement (d).
- Finding the free fall acceleration (g) by knowing both of (t) and (d) and applying the second law of motion.

3. Tools :

1. A jar of water provided with a tap that controls water dripping.
2. A stopwatch.
3. A metal dish to produce sounds of water splashes.
4. Meter tape.



4. Procedure :

1. Adjust the metal dish directly below the tap opening at a distance (d = 1 m).
2. Control the tap to allow a water drop to fall just at the instant of hearing the previous drop hitting the dish base. Accordingly, the time taken by the drop to fall becomes equal to the time between dripping two successive drops from the tap.
3. Record the time taken by 50 successive drops to drip using the stopwatch.
   Then find the time between two successive drops (t) which is the time of drop falling.

$$t = \frac{\text{Total time}}{\text{Number of drops}}$$

4. Repeat the previous procedure several times then find the average time taken by one drop to fall.
5. Find the acceleration due to gravity (g) using the second equation of motion, where :

$$d = v_i t + \frac{1}{2} a t^2$$

$\because v_i = 0$, $a = g$

$\therefore d = \frac{1}{2} g t^2$ $\therefore g = \frac{2d}{t^2}$

Example

In an experiment to determine the acceleration due to gravity using falling water drops, the distance between the tap and the plate base was (1 m). If the time taken by 100 drops is 45 s to fall and reach the plate, find the acceleration due to gravity.

Solution

$v_i = 0$ | $d = 1$ m | $t_{100} = 45$ s | $n = 100$ | $g = ?$

Time taken by one drop to fall (t) $= \frac{\text{Total time}}{\text{Number of drops}} = \frac{t_{100}}{n} = \frac{45}{100} = 0.45$ s

Substituting in the second equation of motion :

$d = v_i t + \frac{1}{2} g t^2 = \frac{1}{2} g t^2$

$g = \frac{2d}{t^2} = \frac{2 \times 1}{(0.45)^2} = 9.88$ m/s^2

Test yourself

Choose :

1. Which of the following statements is correct for a body that is falling freely ? ..... ($g = 9.8$ m/s^2)
   - (a) The body falls a distance of 9.8 m after passing the first second
   - (b) The body falls a distance of 9.8 m every second
   - (c) The acceleration of the body changes by 9.8 m/s^2 every second
   - (d) The average velocity of the body during the first second is 4.9 m/s

2. A metallic ball falls freely and passes by 4 levels J, K, L, M that are at equal distances from each other as in the opposite figure, then .....

J -------
K -------
L -------
M -------

	The maximum velocity of the ball is between	The minimum time taken by the ball is between
(a)	J , K	J , K
(b)	J , K	L , M
(c)	L , M	J , K
(d)	L , M	L , M

UNIT 2

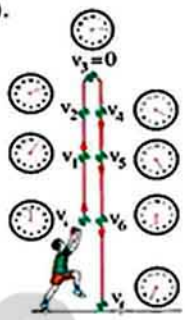
Second Projectiles

The projectiles are classified into :

- Vertical projectiles.
- Two-dimensional projectiles.

Vertical projectiles

- When an object is projected vertically upwards, it starts at initial velocity (v_i) which does not equal zero and moves with uniform deceleration ($-10\ m/s^2$).
- The velocity of the object decreases gradually as the object gets higher and reaches zero at maximum height.
- The direction of velocity changes when the object returns back to the ground under the effect of Earth's gravity that makes the object accelerate ($10\ m/s^2$).
- The velocity of the object when it is projected up = – its velocity at the same level (height) when it is falling down
- The time of rising to the maximum height = The time of falling to the same level of projection



Example 1

An object is projected vertically upwards at initial velocity 98 m/s. Find :

(a) The maximum height reached by the object.

(b) The time taken to reach that height. ($g = 9.8\ m/s^2$)

Solution

$v_i = 98\ m/s$ $v_f = 0$ $g = -9.8\ m/s^2$ $d = ?$ $t = ?$

(a) $v_f^2 - v_i^2 = 2\,gd$

$$d = \frac{v_f^2 - v_i^2}{2g} = \frac{0 - (98)^2}{2 \times (-9.8)} = 490\ m$$

(b) $v_f = v_i + gt$

$$t = \frac{v_f - v_i}{g} = \frac{0 - 98}{-9.8} = 10\ s$$

Example 2

A ball is projected vertically downwards with initial velocity 8 m/s from a height of 30 m. Calculate the time taken by the ball to reach the ground. ($g = 9.8\ m/s^2$)

Solution

$v_i = 8$ m/s | $d = 30$ m | $g = 9.8$ m/s^2 | $t = ?$

$v_f^2 = v_i^2 + 2gd = (8)^2 + (2 \times 9.8 \times 30)$

$v_f = 25.53$ m/s

$v_f = v_i + gt$

$25.53 = 8 + 9.8\,t$

$t = 1.79$ s

Another Solution :

$d = v_i t + \frac{1}{2} g t^2$

$30 = 8\,t + (\frac{1}{2} \times 9.8 \times t^2)$

$4.9\,t^2 + 8t - 30 = 0$

By using the calculator to solve the equation :

$\therefore t = 1.79$ s

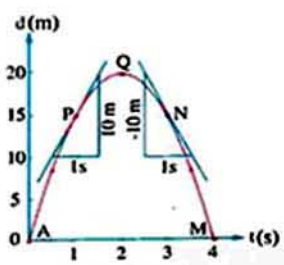
Example 3

The table below records time, displacement and velocity of an object projected vertically upwards at initial velocity 20 m/s :

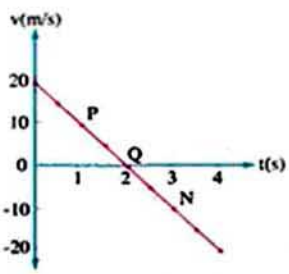
Time (s)	0	0.5	1	1.5	2	2.5	3	3.5	4
Displacement (m)	0	8.75	15	18.75	20	18.75	15	8.75	0
Velocity (m/s)	20	15	10	5	0	– 5	– 10	– 15	– 20

This motion can be represented by the following diagrams :

Projectile trajectory



Change of displacement with time



Change of velocity with time

(a) Determine the object velocity at the points P, Q and N in the (displacement - time) graph and in the (velocity - time) graph.

(b) What is the value of the line slope in the (velocity - time) graph? What does it represent? Why has it got a negative sign?

(c) Calculate the distance and displacement from the start to the end of the journey.

Solution

(a) From the (displacement - time) graph :

The velocity of the body at any point equals the slope of the tangent of the curve at that point.

Slope $= \frac{\Delta d}{\Delta t} = v$

$v_P = \frac{\Delta d}{\Delta t} = \frac{20 - 10}{1.5 - 0.5} = \frac{10}{1} = 10$ m/s

$v_Q = 0$

$v_N = \frac{\Delta d}{\Delta t} = \frac{10 - 20}{3.5 - 2.5} = \frac{-10}{1} = -10$ m/s

From the (velocity - time) graph, we obtain the same values.

(b) Slope of line $= \frac{\Delta v}{\Delta t} = \frac{0 - 20}{2 - 0} = -10$ m/s^2

The slope of line represents the acceleration of the object (free fall acceleration).

The negative sign indicates that the object velocity decreases as it goes further from the ground.

(c) Distance (s) = 20 + 20 = 40 m , Displacement (d) = zero

Test yourself

A ball was projected vertically upwards to reach its maximum height (h) after 3 s, **calculate** the value of (h). ($g = 10$ m/s^2)

.....

.....

.....

.....

QUESTIONS ON
Chapter 2
LESSON TWO

Applications of Motion with Uniform Acceleration
(Free Fall - Vertical Projectiles)

Interactive test

First Multiple choice questions

1. When an object falls freely, its ..... changes from one point to another.
   (a) mass (b) velocity (c) acceleration (d) weight

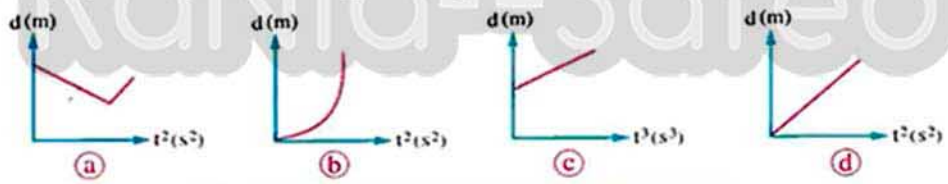
2. Two bodies of different materials having the same volume fall freely together from the same height. Which statement describes correctly their arrival to the ground? ..... .
   (a) The heavier body reaches first (b) The lighter body reaches first
   (c) The heavier body accelerates more (d) They reach the ground at the same time

3. If a body falls freely from a building of height (d) where it takes time (t) to reach the base of the building, then the height of the building is given by the relation : .....
   (a) $d = gt$ (b) $d = gt^2$ (c) $d = \frac{1}{2} gt$ (d) $d = \frac{1}{2} gt^2$

4. An object falls freely. Given that ($g = 9.8\ m/s^2$), its velocity 2 seconds later becomes ..... .
   (a) 4 m/s (b) 4.9 m/s (c) 19.6 m/s (d) 25 m/s

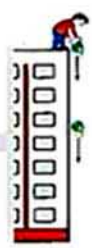
5. If a body falls freely where its velocity after covering a distance of 1 m from the start of its falling is v, then its velocity after 1 s from the start of its falling is ..... .
   (a) v^2 (b) 2 v (c) $\frac{v^2}{2}$ (d) $\sqrt{2}\ v$

6. The graph that represents an object falling freely is labeled ..... .



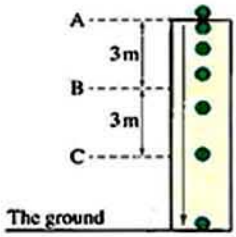
(a) (b) (c) (d)

7. A man drops a stone from the top of a building and when the stone covers 10 m the man drops another stone. If the height of the tower is 100 m, then the time difference between the dropping of the two stones is ..... . ($g = 10\ m/s^2$)
   (a) $\frac{1}{2}$ s
   (b) $\sqrt{2}$ s
   (c) 2 s
   (d) $2\sqrt{2}$ s



UNIT 2

8 The opposite figure shows a ball that falls freely from position A , so the ratio between the velocity of the ball at position B and at position C is ..... respectively. ($g = 10\ m/s^2$)



ⓐ $\frac{1}{4}$ ⓑ $\frac{1}{2}$

ⓒ $\frac{1}{\sqrt{3}}$ ⓓ $\frac{1}{\sqrt{2}}$

9 An object falls from the top of a building of height (2 d), then it reaches the middle of the building after time (t), so it covers the other half of the building during time ..... .

ⓐ $\sqrt{2}$ t ⓑ 0.5 t ⓒ 0.33 t ⓓ 0.41 t

10 The body A falls freely from a height (h) towards the ground and at the same instant the body B is projected vertically upwards. If the two bodies meet at height ($\frac{h}{3}$), then ..... .

ⓐ $\frac{a_A}{a_B} > 1$ ⓑ $\frac{a_A}{a_B} = 1$ ⓒ $0 < \frac{a_A}{a_B} < 1$ ⓓ $\frac{a_A}{a_B} = 0$

11 Two balls of the same volume are projected vertically upwards from the same level with the same initial velocity, where one of them is metallic and the other is wooden. If the density of the metal is larger than the density of the wood, then ..... .
(neglecting the air resistance)

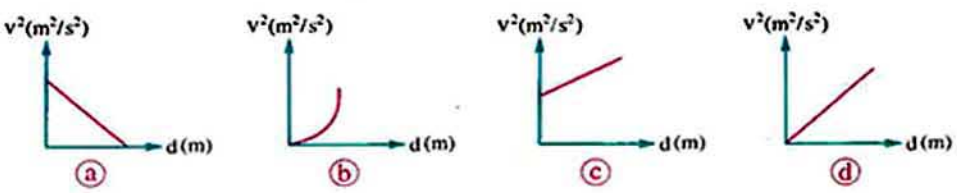
ⓐ the two balls reach the maximum height at the same instant

ⓑ the metallic ball reaches the maximum height first

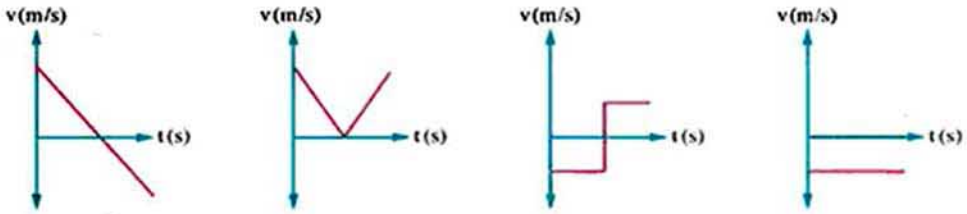
ⓒ the wooden ball reaches the maximum height first

ⓓ we can't determine the answer

12 The graph that represents an object projected vertically upwards at an initial velocity (v_i) till it reaches its maximum height is ..... .



13 The graph that best describes an object projected vertically upwards and returned back to the point of projection, having the direction of initial velocity positive, is ..... .



(a) (b) (c) (d)

14 A rock is projected vertically upwards where it reaches the maximum height (d) after time (t), then it falls freely till it reaches the same point of projection. So, its average velocity equals ..... .

(a) zero (b) $\frac{d}{t}$ (c) $\frac{2d}{t}$ (d) $\frac{d}{2t}$

15 Two balls are projected vertically upwards such that the velocity of the 1st is twice that of the second, then the ball with the higher velocity reaches a height equals ..... .

(a) twice the other (b) $\sqrt{2}$ of the height of the other
(c) 4 times the other (d) 8 times the other

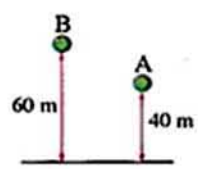
16 The highest jump recorded by a player in a basketball game was 1.25 m, so the flight's time of this player is ..... . ($g = 10\ m/s^2$)

(a) 0.05 s (b) 0.25 s (c) 0.5 s (d) 1 s

17 Two objects A and B are projected from the top of a building with the same velocity, where A is projected upwards and B is projected downwards. If the mass of A is greater than the mass of B, then ..... when reaching the ground (by neglecting the air resistance).

(a) the velocity of A is greater than the velocity of B
(b) the velocity of A is less than the velocity of B
(c) the velocity of A equals the velocity of B
(d) the velocities of A and B equal zero

18 Body A falls freely on the ground and at the same instant body B was projected downwards to the ground with initial velocity v. If the two bodies reaches the ground at the same instant, then the value of v is ..... . ($g = 10\ m/s^2$)



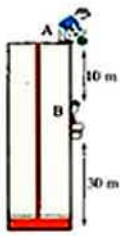
(a) $2\sqrt{2}$ m/s (b) $10\sqrt{10}$ m/s (c) $5\sqrt{2}$ m/s (d) $2\sqrt{5}$ m/s

UNIT 2

19 An object is projected vertically upwards with a velocity of 15 m/s from a height of 20 m above the Earth's surface, so its velocity when it hits the ground is ..... . ($g = 10\ m/s^2$)

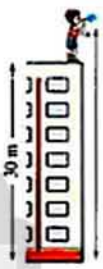
(a) 20 m/s (b) 35 m/s (c) 25 m/s (d) 15 m/s

20 The boy A projects a ball downwards with velocity v, where it reaches the boy B after 0.5 s. So, the ball reaches the ground after time ..... from the moment of projection. ($g = 10\ m/s^2$)



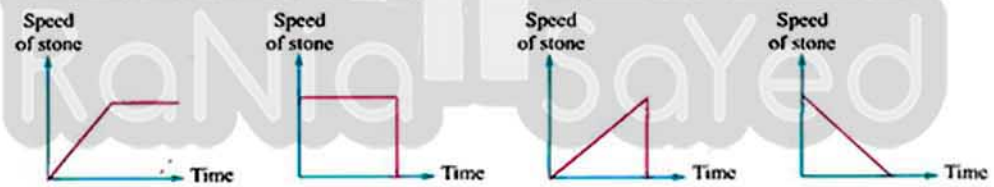
(a) 6.88 s (b) 3.14 s
(c) 0.53 s (d) 1.58 s

21 A boy projects a ball vertically upwards with velocity v from the top of a building where it rises and then it falls down to hit the ground with velocity 2 v. So, the total distance covered by the ball is ..... . ($g = 10\ m/s^2$)



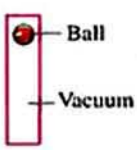
(a) 30 m (b) 60 m
(c) 50 m (d) 120 m

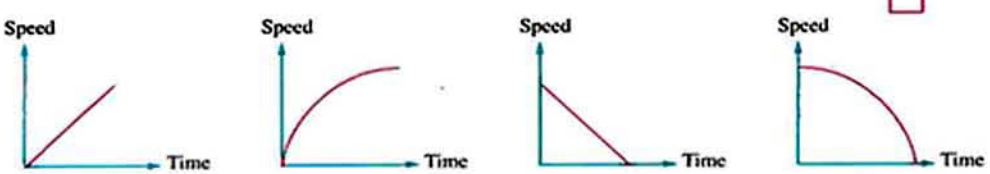
22 A small stone is dropped from the top of a ladder and hits the ground. It does not rebound. Which (speed - time) graph is correct ? ..... .



(a) (b) (c) (d)

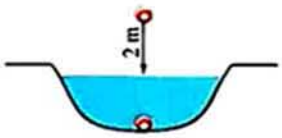
23 A table - tennis ball is released from the top of an evacuated tube. Which graph shows how the speed of the ball changes with time as it falls to the bottom of the tube ? ..... .





(a) (b) (c) (d)

24 A metallic ball falls from a height of 2 m towards the surface of a lake, its velocity when it hits the water was v, then it moves inside the water by an average velocity of 0.2 v for 5 s till it reaches the bottom of the lake, so the depth of this lake is ..... . ($g = 10\ m/s^2$)



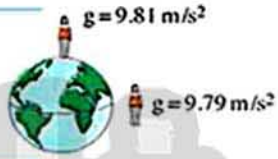
(a) $2\sqrt{5}$ m (b) $10\sqrt{2}$ m (c) $2\sqrt{10}$ m (d) 5 m

Second Essay questions

1 If the velocity of a body equals zero at an instant, is it necessary that its acceleration at the same instant equals zero ? **Give an example.**

2 **From the opposite figure :**

Explain why the free fall acceleration varies from one position to another.



3 **Explain the following sentences :**

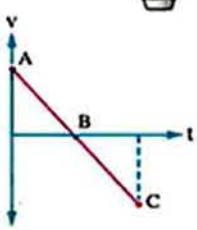
(1) When an object falls freely from rest, its velocity increases.

(2) The velocity of a body that is projected vertically upwards decreases till it reaches zero.

(3) At maximum height, the acceleration of the projected object does not equal zero.

4 In the opposite figure there is a tube which is vacuumed from air, if the tube is inverted **which of the following will be larger** the rate of change of the coin's velocity or the rate of change of the feather's velocity ? **And why ?**

5 **Study the opposite graph which represents the motion of an object under the effect of gravity and answer :**



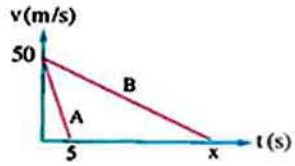
(a) **Describe** the kinematic state of the object.

(b) **What do** the points (A) and (C) represent? **What is the relation between them?**

(c) **What does** the point (B) represent?

UNIT 2

6 The opposite graph represents the projection of two objects vertically; one on the Earth while the other on the Moon. Given that the acceleration due to gravity on the Moon is $\frac{1}{6}$ that on the Earth ($g = 10\ m/s^2$), answer :



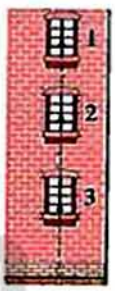
(a) Which line represents the projection of the object on the Earth?

(b) Why do the two lines (A) and (B) have different slopes?

(c) Estimate the time value at the point (x).

(d) What would happen to the slope of the two lines when the mass of the object is doubled in both cases ? And why ?

7 The opposite figure shows the path of a ball that is projected vertically upwards to pass in front of three identical windows which have equal lengths and are at equal distances from each other, arrange these windows in a descending order according to :



(a) The acceleration of the ball while passing by each one of them.

(b) The time taken by the ball while passing by each one of them.

(c) The average velocity of the ball while passing by each one of them.

(d) The change in the velocity of the ball (Δv) while passing by each one of them.

Third Problems

1 Two bodies of masses 5 kg and 25 kg fall freely at the same time from a point 10 m high above the ground. Which body reaches the ground first? Neglect the air resistance and consider ($g = 9.8\ m/s^2$). Then calculate the time taken by each body to reach the ground. (1.43 s, 1.43 s)

2 An object falls freely from 3.2 m high above the Moon surface. If it takes 2 s to reach the surface, find the acceleration due to Moon's gravity. ($1.6\ m/s^2$)

3 An object falls from 5 m high above the ground. Find its velocity when reaching the ground and the time taken. ($g = 9.8\ m/s^2$) (9.9 m/s, 1.01 s)

4 An object falls from a tower to reach the ground 6 s later. If the free fall acceleration is $9.8\ m/s^2$, find :

(a) The object velocity when reaching the ground.

(b) The tower height.

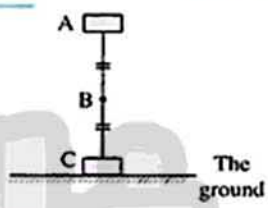
(c) The distance covered during the last 2 s. (58.8 m/s, 176.4 m, 98 m)

5 A stone falls from the edge of a well that contains water at 122.5 m from the edge of the well. **How many** seconds will pass to hear the sound of the stone hitting the water ? (knowing that : the velocity of the sound in air = 343 m/s) (5.36 s)

6 In an experiment to determine the free fall acceleration due to gravity using water drops that fall freely, the distance between the tap and the plate base is (123 cm). If the time taken by 50 drops is 25 s, **find** the free fall acceleration. ($9.84\ m/s^2$)

7 A piece of lead was thrown in a lake from 10 m high above the lake's surface, when it reaches the surface of the water its velocity was (v) then the velocity starts to decrease and it dives at an average velocity equals (0.1 v) to reach the bottom of the lake after 6.5 s. **Calculate** the depth of the lake. ($g = 10\ m/s^2$) (9.19 m)

8 An object falls freely as in the opposite figure from point (A) to point (C) and point (B) is in the middle of the distance. **Calculate** the ratio between the time of motion of the object from (A ⟶ B) and the time of motion from (A ⟶ C). $(\frac{1}{\sqrt{2}})$



9 An object is projected vertically upwards to reach maximum height of 80 m. If $g = 9.8\ m/s^2$. **Find :**

(a) The velocity of projection.

(b) The time taken till the object returns back to the point of projection. (39.6 m/s, 8.08 s)

10 A body was projected vertically upwards with initial velocity 98 m/s, if the free fall acceleration is $9.8\ m/s^2$, **calculate :**

(a) The velocity of the body after 5 s from the instant of projection.

(b) The maximum height reached by the body.

(c) The total time taken by the body from the point of projection till it returns back to it.

(49 m/s, 490 m, 20 s)

11 An object was projected upwards with initial velocity 60 m/s, **calculate :**

(a) The time required to reach a velocity of 20 m/s.

(b) The height of the object when its velocity equals 20 m/s.

(c) The time required for the object to return back to its initial point.

(d) The maximum height. (4 s, 160 m, 12 s, 180 m)

12 A stone is thrown at velocity 96 m/s into a well to reach the bottom 3 s later. **Find** the well depth. ($g = 9.8\ m/s^2$) (332.1 m)

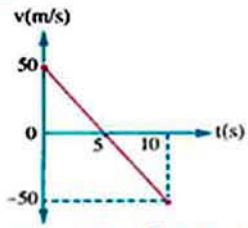
13 A body of mass 3 kg was projected vertically upwards by initial velocity 40 m/s, **calculate :**

(a) The maximum height reached by the body.

(b) The total time taken by the body till it returns back to the point of projection. (80 m, 8 s)

14 A body (A) was projected vertically upwards by initial velocity 20 m/s, after that by one second body (B) was projected from the same point of projection, **calculate** the initial velocity that makes body (B) collides with body (A) at the maximum height. (25 m/s)

15 The opposite graph represents the relation between velocity and time of a projectile. **Find :**



(a) The time taken to reach maximum height.

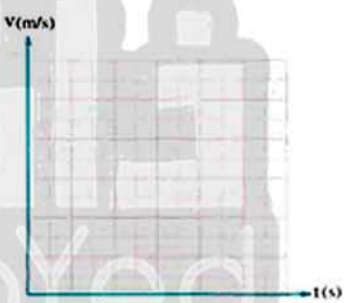
(b) The total time taken by the object for its flight.

(c) The free fall acceleration.

(d) The maximum height reached by the object.

(5 s , 10 s , - 10 m/s^2 , 125 m)

16 A rocket starts its motion vertically upwards from rest and moves with uniform acceleration until its velocity reaches 900 m/s after 30 s. At this instant the rocket's engine crashes and the rocket's velocity decreases uniformly for 90 s during its elevation until it vanishes :



(a) **Draw** on the opposite graph paper the (velocity - time) graph of the rocket's motion during its elevation for 120 s.

(b) **By using your drawing, calculate :**

1- The acceleration of the rocket during the first 30 s.

2- The height reached by the rocket after 120 s. (30 m/s^2, 54 km)

17 The table below shows the relation between the displacement of an object falling freely and square of time :

d (m)	0	4.9	19.6	A	78.4	122.4
t^2 (s^2)	0	1	4	9	16	B

(a) **Plot** the graphical relation between displacement on y-axis and square of time on x-axis.

(b) **From the graph find :**

1- The values of A and B.

2- The free fall acceleration.

3- The object velocity after 4 s. (44.1 m, 25 s^2, 9.8 m/s^2, 39.2 m/s)

Chapter 2

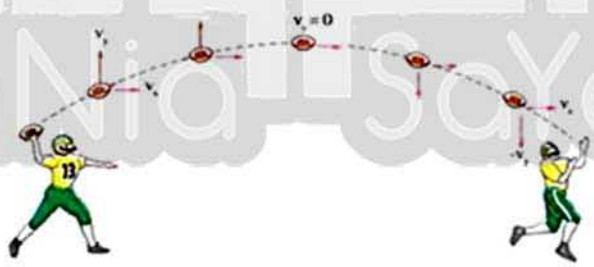
LESSON THREE

Follow Applications of Motion with Uniform Acceleration (Two-Dimensional Projectiles)

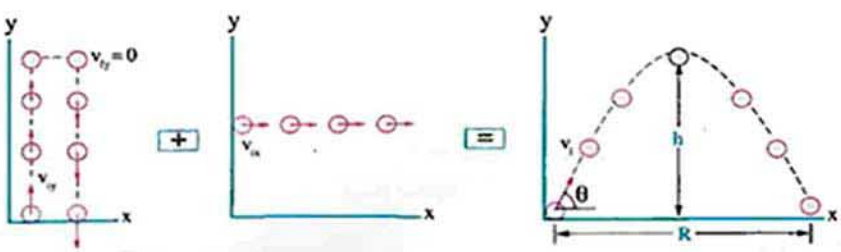
Two-dimensional projectiles (projectiles projected at an angle) :

Projectiles projected at an angle (Motion in two dimensions)

- When a ball is projected upwards with initial velocity (v_i) at an angle (0) with the horizontal, it moves in a curved path as shown in the figure :



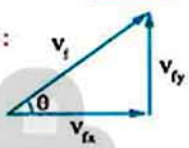
- We can resolve velocity in two dimensions ; horizontal (x) and vertical (y) as shown :



UNIT 2

In the horizontal dimension (x)	In the vertical dimension (y)
The initial velocity	
$v_{ix} = v_i \cos\theta$	$v_{iy} = v_i \sin\theta$
The final velocity (by using equations of motion)	
The ball moves with uniform velocity (assuming that there is no frictional forces).	The ball moves with variable velocity under the effect of the free fall acceleration.
$\because a_x = 0$	$\because a_y = -g$
$\therefore v_{fx} = v_{ix}$	$\therefore v_{fy}$ can be calculated at any instant from any height.

⊙ The velocity of the projectile at any instant is given by Pythagoras' relation :



$$v_f = \sqrt{v_{fx}^2 + v_{fy}^2}$$

⊙ **Finding the time of reaching the maximum height (t) and the flight time (T) :**

$v_{fy} = v_{iy} + gt$

When the body reaches the maximum height, the velocity in the vertical direction (y) vanishes. So, we substitute with ($v_{fy} = 0$) in the first equation of motion : $0 = v_{iy} + gt$

$$\therefore t = \frac{-v_{iy}}{g}$$

The flight time (T) : The time taken by the body from its initial point of motion till returning back to the plane of projection is double the time of reaching the maximum height (t) :

$$\therefore T = 2t = \frac{-2v_{iy}}{g}$$

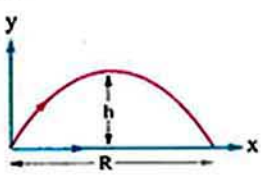
⊙ **Finding the maximum height reached by the projectile (h) :**

- When the body reaches the maximum height, the velocity in the vertical direction (y) vanishes ($v_{fy} = 0$), but it has a velocity in the horizontal direction (v_{fx}).

• From the third equation of motion :

$2ad = v_{fy}^2 - v_{iy}^2$, $2gh = 0 - v_{iy}^2 = -v_{iy}^2$

$$\therefore h = \frac{-v_{iy}^2}{2g}$$



⊙ Finding the horizontal range (the horizontal distance reached by the projectile) (R) :

∵ Time of the maximum horizontal range = Flight time = T

Substituting by ($a_x = 0$) and (d = R) in the second equation of motion :

$$\therefore \quad R = v_{ix}\, T = 2\, v_{ix}\, t = \frac{-2\, v_{ix}\, v_{iy}}{g} = \frac{-2\, v_i^2 \cos\theta \sin\theta}{g}$$

Notes :

- It is important to know that the horizontal and the vertical motion of the projectile are not dependent on each other, where their effects together produce the curved trajectory of the projectiles.
- The opposite figure shows the change in the position of two balls through equal intervals of time where one of them is projected horizontally and the other is left to fall freely at the same time (neglecting the air resistance).

- The ball that falls freely in a straight line, it falls under the effect of its weight and its motion can be described by using the equations of motion with uniform acceleration in one direction where a = g
- The ball that is projected horizontally, it moves a horizontal distance with constant horizontal velocity that is given by the relation : $\Delta x = v\, \Delta t$, and the ball's motion on the vertical axis is the same as the motion of the free falling ball where its initial vertical velocity equals zero, so it covers at any instant the same vertical distance covered by the free falling ball. Because of this the two balls reach the ground at the same instant and it is clear that there is no relation between the covered distance during falling and the horizontal component of motion.
- The summary of this is that : The projectile motion consists of two components of motion which are the uniform velocity motion on the horizontal axis and the uniform acceleration motion on the vertical axis.

Example 1

A motorcycle is launched at 15 m/s in a direction that makes an angle of 30° to the horizontal. Find :

(a) The maximum height reached by the motorcycle.

(b) The time of its flight.

(c) The horizontal range reached by the motorcycle. ($g = 10\ m/s^2$)

Solution

$v_i = 15$ m/s | $\theta = 30°$ | $h = ?$ | $T = ?$ | $R = ?$

$v_{ix} = v_i \cos 30° = 15 \times 0.866 = 13$ m/s

$v_{iy} = v_i \sin 30° = 15 \times 0.5 = 7.5$ m/s

(a) The maximum height $(h) = \frac{-v_{iy}^2}{2g} = \frac{-(7.5)^2}{2 \times (-10)} = 2.8$ m

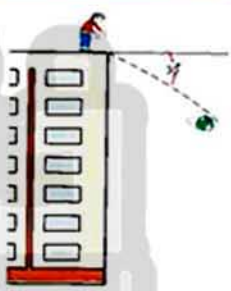
(b) The time of the flight $(T) = 2t = \frac{-2 v_{iy}}{g} = \frac{-2 \times 7.5}{-10} = 1.5$ s

(c) The horizontal range $(R) = v_{ix} T = 13 \times 1.5 = 19.5$ m

Example 2

In the opposite figure :

A man that stands at the top of a building, launches a ball with initial velocity 40 m/s in a direction that makes an angle of 30° with the horizontal. If the ball spent 4 s to reach the Earth's surface :



(a) What is the building's height?

(b) How far does the ball fall from the base of the building ?

(c) If the same man projects another ball horizontally to reach the ground at the same point as the previous case, calculate the velocity by which the ball is projected. $(g = 10\ m/s^2)$

Solution

$v_i = 40$ m/s | $\theta = 30°$ | $t = 4$ s | $g = 10\ m/s^2$ | $h = ?$ | $d = ?$ | $v_i = ?$

(a) $v_{iy} = v_i \sin \theta = 40 \sin 30° = 20$ m/s

$h = v_{iy} t + \frac{1}{2} g t^2 = (20 \times 40) + \frac{1}{2} \times 10 \times 4^2 = 160$ m

(b) $v_{ix} = v_i \cos \theta = 40 \times \cos 30° = 34.64$ m/s

$R = v_{ix} t = 34.64 \times 4 = 138.56$ m

(c) **Clue**

When the ball is projected horizontally, its initial vertical velocity will equal zero. So, the initial velocity of the ball is the horizontal velocity only.

$h = v_{iy} t + \frac{1}{2} g t^2$

$160 = 0 + \left(\frac{1}{2} \times 10\, t^2\right)$

$t = 4\sqrt{2}$ s

$d = v_{ix}\, t$

$v_{ix} = \frac{d}{t} = \frac{138.56}{4\sqrt{2}} = 24.49$ m/s

∵ When the ball is projected horizontally, its initial velocity becomes horizontal velocity only.

∴ $v_i = v_{ix} = 24.49$ m/s

Example 3

A fish is moving in the water when it jumps outside the water with velocity 6.26 m/s at an angle of 45° to the horizontal, it covers a horizontal distance L till it hits the water again, then it moves the same distance inside the water with velocity 3.58 m/s before it jumps again. Calculate :

(a) The average velocity of the fish during its motion inside and outside the water.

(b) The percentage of the decrease in the time of motion, when the fish moves by this way instead of moving inside the water only with velocity 3.58 m/s. ($g = 9.8$ m/s^2)

Solution

(a)

Clue

To determine the average velocity of the fish during its motion, we should determine :

- *The total displacement of the fish inside and outside the water which is the horizontal distance moved by the fish inside the water added to the horizontal distance moved by it outside the water.*
- *The total time taken by the fish which is the summation of the time of motion inside the water and outside it.*

$T_1 = \frac{-2\, v_{iy}}{g} = \frac{-2\, v_i \sin\theta}{g} = \frac{-2 \times 6.26 \sin 45}{-9.8} = 0.904$ s

$R = L = v_{ix}\, T = v_i \cos\theta\, T = 6.26 \cos 45 \times 0.904 = 4$ m

- When the fish moves inside the water :

$\therefore t_2 = \frac{L}{v} = \frac{4}{3.58} = 1.117$ s

- The total time of motion :

$T = T_1 + t_2 = 0.904 + 1.117 = 2.021$ s

$\therefore \bar{v} = \frac{2L}{T} = \frac{2 \times 4}{2.021} = 3.96$ m/s

(b)

Clue

When the fish moves inside and outside the water, the time of its motion will be less than the time of its motion if it moves inside the water only. This decrease in time is the ratio of the difference between the two periods of time to the time of the fish's motion inside the water.

- If the fish moves inside the water only :

$t = 2\,t_2 = 2 \times 1.117 = 2.234$ s

$\Delta T = t - T = 2.234 - 2.021 = 0.213$ s

$\therefore$ The percentage of the decrease in the time $= 100 \times \frac{0.213}{2.234} = 9.5\ \%$

Do you know ...?

1. The projectile reaches maximum horizontal range when it is projected at an angle 45°.
2. The horizontal range is the same when the projectile is projected at complementary angles and at the same initial velocity (angles of sum 90°).

Test yourself

1. A body is projected at angle θ to the horizontal, so **at what point** is the direction of the body's velocity perpendicular on the direction of the body's acceleration ? **And at what point** are they parallel ?

.....

.....

2. If the initial velocity of launching a projectile equals 5 times its velocity at the maximum height reached by it, **calculate** the angle of its projection.

.....

.....

.....

QUESTIONS ON
Chapter 2
LESSON THREE

Follow Applications of Motion with Uniform Acceleration
(Two-Dimensional Projectiles)

Interactive test

First Multiple choice questions

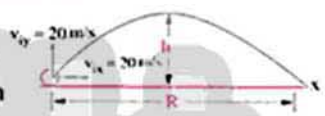
1. When the projectile which is projected at an angle reaches the same horizontal level after time T, then it reaches the maximum height after time ..... .

ⓐ $\frac{1}{2}$ T ⓑ T ⓒ 2 T ⓓ T^2

2. If an object is projected upwards at an angle of 30° to the horizontal and its initial velocity is 20 m/s, its maximum height = ... (consider : g = 10 m/s^2)

ⓐ 5 m ⓑ 10 m ⓒ 15 m ⓓ 20 m

3. The opposite figure shows an object that is projected at an angle, if : (g = 10 m/s^2)



(i) the maximum vertical height reached by the object is given by the relation : $h = \frac{-(v_{iy})^2}{2g}$, then the value of h is .....

ⓐ 400 m ⓑ 100 m ⓒ 20 m ⓓ 10 m

(ii) the maximum horizontal range reached by the object is given by the relation : $R = \frac{-2v_{ix}v_{iy}}{g}$, then the value of R is .....

ⓐ 800 m ⓑ 80 m ⓒ 200 m ⓓ 20 m

4. When an object is projected at initial velocity (v_i) in a direction making an angle of 60° to the horizontal to reach a horizontal range R. To make the projectile reach a greater range, it should be projected at the same initial velocity and angle .....

ⓐ 90° ⓑ 75° ⓒ 45° ⓓ 30°

5. The horizontal range reached by two identical projectiles is the same when they are projected at same initial velocity at angles .....

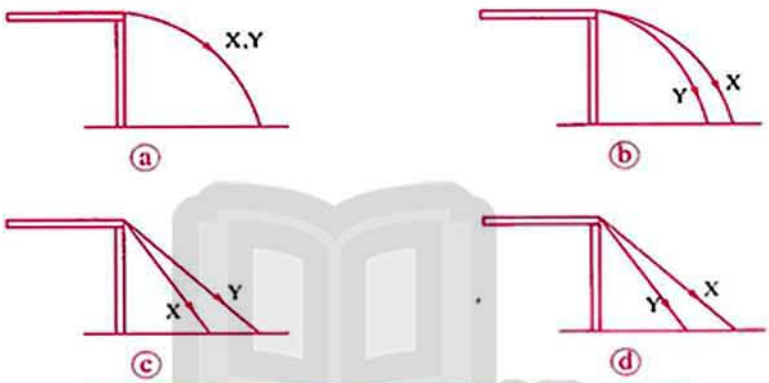
ⓐ 80° and 30° ⓑ 80° and 60° ⓒ 50° and 40° ⓓ 20° and 80°

6. A body is projected at angle ..... with the horizontal, where the maximum height (h) reached by it equals $\frac{R}{4}$.

ⓐ 30° ⓑ 45° ⓒ 60° ⓓ 75°

UNIT 2

7 There are two balls X and Y rolling together from the top of a table with the same horizontal velocity, where the mass of X is greater than the mass of Y. If we neglect the air resistance, which of the following figures describes the motion of the two balls ? ..... .



(a) (b) (c) (d)

8 A projectile was projected with velocity v and then it was projected with velocity $\frac{v}{2}$ from the same height and by the same angle of projection, so the ratio between the horizontal range of the projectile in the first case and the horizontal range of it in the second case equals .....

(a) $\frac{4}{1}$ (b) $\frac{2}{1}$ (c) $\frac{1}{2}$ (d) $\frac{1}{4}$

9 Three identical balls are projected at the same moment from the same point with the same velocity, where the first ball is projected vertically upwards and the second ball is projected at an angle of 45° to the horizontal and the third ball is projected at an angle of 60° to the horizontal. So the ball that hits the ground first is .....

(a) the first ball
(b) the second ball
(c) the third ball
(d) all the balls reach the ground at the same moment

10 Two projectiles A and B were projected with the same velocity, where θ is the angle made by the projectile A with the horizontal and also it is the angle made by the projectile B with the vertical, then ..... (where $\theta < 45°$)

(a) they have the same flight time
(b) they reach the same maximum height
(c) they have the same horizontal range
(d) all the previous

11 A boy projects a ball with velocity 10 m/s at an angle of 30° to the horizontal from the top of a building of height 10 m. So, the maximum distance reached by the ball at the same level of projection is ..... ($g = 10\ m/s^2$)

(a) 5.2 m (b) 4.33 m (c) 2.6 m (d) 8.66 m

12 A body was projected by an angle θ to the horizontal at initial velocity v_i, if $v_{ix} = v_{iy} = 20$ m/s, then v_i and θ values are ..... and ..... respectively.

(a) 40 m/s , 60° (b) $20\sqrt{2}$ m/s , 45° (c) 40 m/s , 45° (d) $20\sqrt{2}$ m/s , 30°

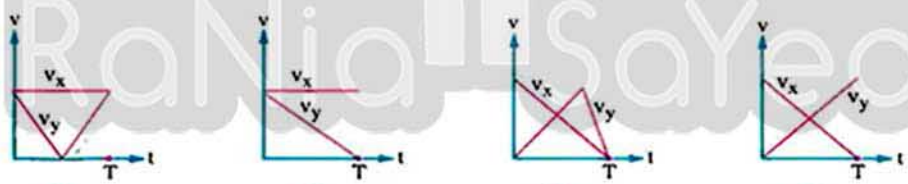
13 A body was projected at an angle of 30° to the horizontal at initial velocity v_i, after 4 s its velocity in the vertical dimension was $\frac{1}{4}\ v_i$, so the value of v_i is ..... ($g = 10\ m/s^2$)

(a) 7.5 m/s (b) 40 m/s (c) 80 m/s (d) 160 m/s

14 A body was projected upwards at an angle θ to the horizontal at initial velocity v_i, if $v_{iy} = 2\ v_{ix}$, then the value of θ is .....

(a) 30° (b) 60° (c) 63.43° (d) 36.51°

15 A projectile was projected from the Earth's surface at t = 0 at angle of 45° to the horizontal, then returns back to the Earth's surface at t = T, so the graph that represents the change in the vertical component of the velocity v_y and the horizontal component of the velocity v_x with time is ..... (neglecting the air resistance)



(a) (b) (c) (d)

16 A bomb fell from a plane flying horizontally with velocity 100 m/s where it was at a height of 4 km from a target, then : ($g = 10\ m/s^2$)

(i) The time taken by the bomb to reach the target equals .....

(a) $15\sqrt{3}$ s (b) $18\sqrt{3}$ s (c) $20\sqrt{2}$ s (d) $25\sqrt{2}$ s

(ii) The horizontal range of the bomb equals ..... .

(a) 1765.4 m (b) 2205 m (c) 2828.4 m (d) 3126.2 m

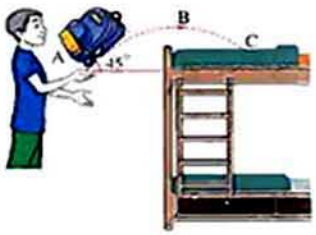
(iii) The final velocity of the bomb equals ..... .

(a) 150 m/s (b) 300 m/s (c) 400 m/s (d) 1000 m/s

UNIT 2

Second Essay questions

1. A student throws his school bag on his bed at an angle of 45° to the horizontal as in the opposite figure where it passes by point A after leaving the student's hand directly then it passes by point B to reach point C before it touches the bed, **arrange :**

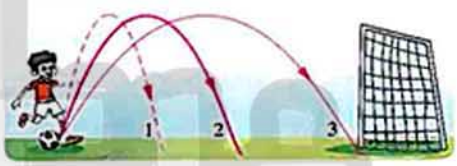


(a) The horizontal components of the bag's velocity at the points A , B and C.

(b) The vertical components of the bag's velocity at the points A , B and C.

(c) The vertical components of the bag's acceleration at the points A , B and C.

2. The opposite figure shows three paths for a football that was projected from the ground. By neglecting the air resistance, **arrange the three paths in a descending order according to :**



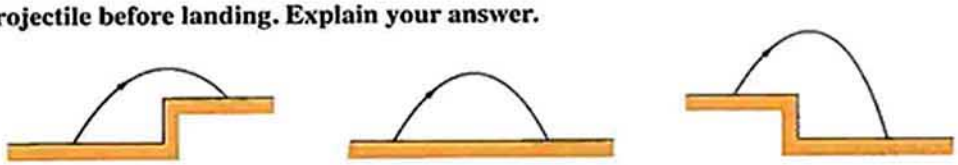
(a) The vertical component of the initial velocity.

(b) The flight time.

(c) The horizontal component of the initial velocity.

(d) The initial velocity.

3. The next figures show three identical projectiles which are projected from the same level with the same velocity at the same angle, but they aren't landing at the same point. **Arrange the three cases in a descending order according to the final velocity of each projectile before landing. Explain your answer.**

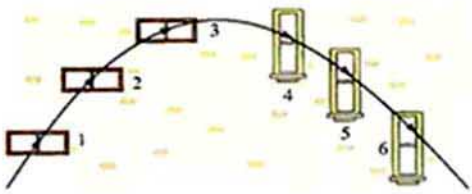


(1) (2) (3)

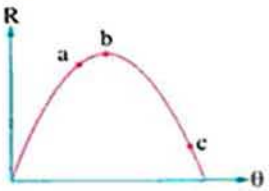
4. The next figure shows the path of a ball that is projected to pass by the windows 1, 2 and 3 while elevating where the windows are identical and at equal vertical distances from each other, then if it passes by the windows 4, 5 and 6 while descending where the windows are also identical and at equal vertical distances from each other. **Arrange the windows (1, 2 and 3) and also the windows (4, 5 and 6) in a descending order according to :**

(a) The time taken by the ball to pass by each window.

(b) The average velocity of the ball while passing by each window.



5 The opposite graph shows the change of the horizontal range (R) of a ball that is projected from the ground with initial velocity (v_i) with the angle (θ) by which the ball is projected from the ground. **Arrange in a descending order the shown points on the graph according to :**



(a) The flight time of the ball.

(b) The velocity at the maximum height reached by the ball.

Third Problems

1 An object is projected at initial velocity 20 m/s at an angle of 60° to the horizontal. **Find :**

(a) The horizontal component of the object velocity.

(b) The initial vertical component of the object velocity.

(c) The vertical component of the object velocity after 1 second from projection. ($g = 10\ m/s^2$)

(10 m/s, 17.32 m/s, 7.32 m/s)

2 A motorbike moved with a velocity of 20 m/s in a direction that makes an angle of 60° to the horizontal.

(a) **What** is the maximum height reached by the bike ?

(b) **What** is the flight time ?

(c) **What** is the maximum horizontal range reached by the bike ?

(knowing that : $g = 10\ m/s^2$) (15 m, 3.464 s, 34.64 m)

3 An object was projected at an angle of 30° to the horizontal and returns back to the ground after 4 s, **calculate :**

(a) The initial velocity by which the object was projected.

(b) The velocity of the object in the horizontal dimension at the instant of projection.

(c) The maximum height reached by the object.

(knowing that : $g = 10\ m/s^2$) (40 m/s, 34.64 m/s, 20 m)

4 A cannon fires projectiles at an angle of 45° to the horizontal, what is the initial velocity required for the projectiles to hit a target 1000 m away from the cannon ? ($g = 10\ m/s^2$)

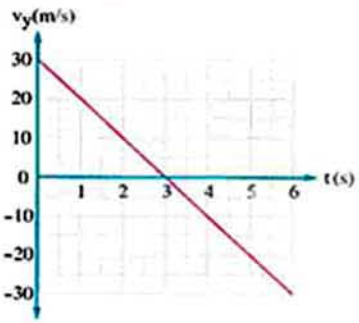
(100 m/s)

5 The opposite graph represents the change in the vertical component of the velocity of a projectile in the gravitational field of Earth. If the angle of projection was 30° to the horizontal, **calculate :**

(a) The velocity by which the object was projected.

(b) The maximum height reached by the object.

(c) The horizontal range. ($g = 10\ m/s^2$)



(60 m/s, 45 m, 311.76 m)

6 **Use the data given in the figure to find** the projection velocity of a cannon ball that is required to hit the ship. ($g = 10\ m/s^2$)

(158.11 m/s)

7 Study the opposite figure that shows the shooting of a projectile from a cannon. **Then answer the following questions.**

(a) **When** does the vertical component of the projectile velocity equal zero?

(b) **What** is the greatest horizontal range of this cannon?

(c) **What** is the time taken to reach a target at that range?

(70.71 s, 100 km, 141.42 s)

8 An officer adjusts a cannon in a training task.

(a) **What** is the angle needed to achieve the greatest horizontal range?

(b) **What** is the velocity of the projected missile if it reached maximum height of 2000 m when projected at an angle of 60° to the horizontal?

(c) If the velocity of the missile at projection is 800 m/s, **what** is its velocity 10 s later if the cannon makes an angle of 10° to the vertical?

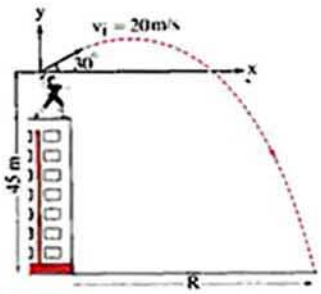
(45°, 230.94 m/s, 701.74 m/s)

9 By using the opposite figure, **calculate :**

(a) The time taken by the ball to reach the ground.

(b) The horizontal distance (R) covered by the ball.

($g = 10\ m/s^2$) (4.16 s, 72.05 m)



10 A person at the roof of a high building has projected a ball at velocity 50 m/s. Given that the acceleration due to gravity is $10\ m/s^2$, **find the velocity and the displacement of the ball after 4 s in the following cases :**

(a) The ball has been projected vertically upwards.

(b) The ball has been projected vertically downwards.

(c) The ball has been projected upwards at an angle of 60° to the horizontal.

(d) The ball has been projected horizontally (zero° to the horizontal).

(10 m/s, 120 m, 90 m/s, 280 m, 25.22 m/s, 136.7 m, 64.03 m/s, 215.4 m)

11 A ball was projected horizontally with velocity 4 m/s to fall on a metallic surface and rebounds as in the opposite figure, by neglecting the air resistance.

(a) **Calculate :**

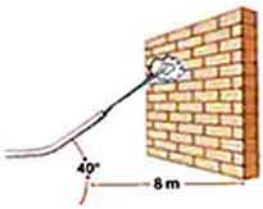
1- The horizontal component of the ball's velocity when it hits the metallic surface.

2- The vertical component of the ball's velocity when it rebounds from the metallic surface.

(b) **Prove that** the vertical component of the ball's velocity when it hits the metallic surface equals 6.2 m/s.

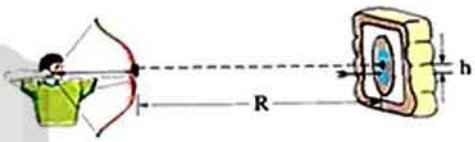
(c) **Draw** a measurable vector representation for the horizontal and the vertical components of the ball's velocity when it hits the metallic surface, **then from the drawing determine** the velocity of the ball when it hits the metallic surface and the angle made by it with the vertical. (4 m/s, 4.38 m/s, 6 m/s, 33°)

12 A hose on the ground projects a water current upwards at an angle of 40° to the horizontal at velocity 20 m/s. **Find** the height at which water hits a wall at 8 m away from the hose.
(consider : $g = 9.8\ m/s^2$)



(5.36 m)

13 An athlete projected an arrow horizontally towards a target, the arrow reaches the target at a point (7.6 cm) under the center of the target. If the distance between the athlete and the target is 10 m and by neglecting the air resistance, **calculate :**



(a) The time taken by the arrow to reach the target.

(b) The initial velocity by which the arrow was projected. (124.5×10^{-3} s, 80.32 m/s)

14 The table below shows the relation between the vertical velocity of an object projected vertically upwards at an angle of 45° to the horizontal and the time of flight in air :

T (s)	2	4	6	8	B	12
v_{iy} (m/s)	10	20	A	40	50	60

(a) **Plot** the graphical relation between (v_{iy}) on x-axis and (T) on y-axis.

(b) **From the graph find :**

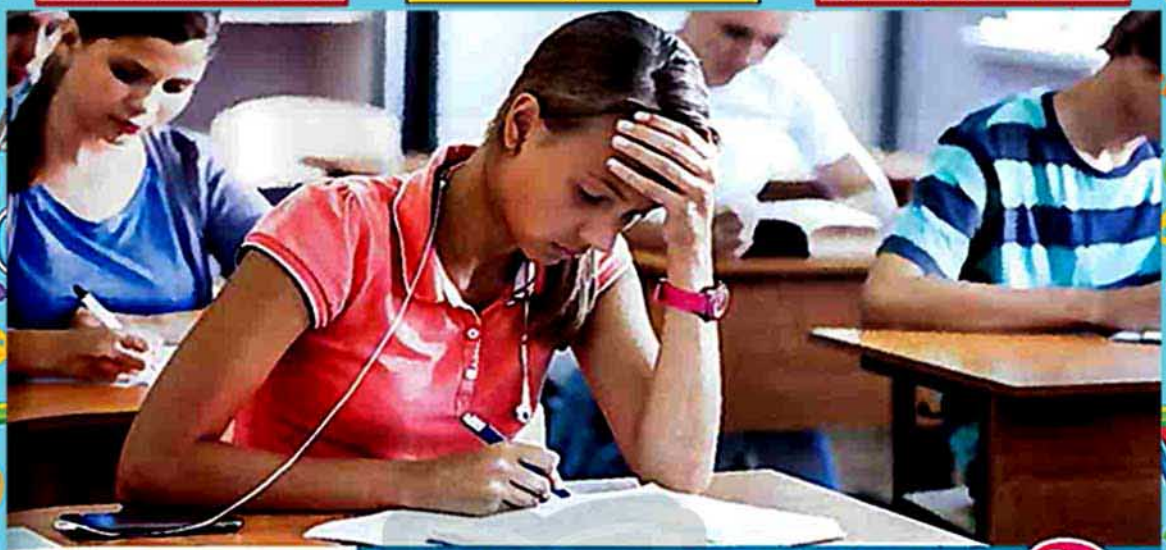
1- The values of A and B.

2- The free fall acceleration.

3- The horizontal component of velocity at a point (A).

4- The horizontal distance covered by the object at the point (B).

(30 m/s , 10 s , – 10 m/s^2 , 30 m/s, 500 m)



MODEL EXAM ON

Chapter 2

Motion with Uniform Acceleration

First Choose the correct answer

1. A body is projected vertically upwards to reach the maximum height and then it returns back to the point of projection after 10 s. If the air resistance is neglected, then the ratio between the velocity of the body at the instant projection and the velocity of the body at the instant of hitting the ground is ..... ($g = 10\ m/s^2$)

   (a) larger than one (b) less than one (c) equal to one (d) no correct answer

2. If a body starts its motion from rest and it moves with uniform acceleration to reach velocity 6 m/s after the third second, then its average velocity in 100 m equals ..... .

   (a) 6 m/s (b) 50 m/s (c) 10 m/s (d) 100 m/s

3. If the maximum height reached by a projectile is 40 m and the maximum horizontal range reached by it is $160\sqrt{3}$ m , then the angle at which the projectile is projected equals ..... .

   (a) 15° (b) 30° (c) 45° (d) 60°

4. A body starts its motion from rest and moves with uniform acceleration 2 m/s^2 to cover a distance 100 m during ..... .

   (a) 2.5 s (b) 5 s (c) 10 s (d) 20 s

5. A projectile is projected with initial velocity of v_i at an angle of 30° to the horizontal and after 4 s it reaches its maximum height, then the value of v_i is .....

   (a) 20 m/s (b) 40 m/s (c) 80 m/s (d) 100 m/s

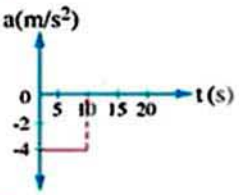
6 A body falls from the top of a building to reach a velocity 20 m/s at the middle of the building, so the height of the building is ..... ($g = 10\ m/s^2$)

(a) 10 m (b) 20 m (c) 30 m (d) 40 m

7 A body is projected with initial velocity 30 m/s at an angle of 30° to the vertical, so its horizontal velocity equals ..... .

(a) 15 m/s (b) $15\sqrt{3}$ m/s (c) $20\sqrt{2}$ m/s (d) $10\sqrt{10}$ m/s

8 The opposite figure represents the deceleration of a plane from the velocity of 60 m/s, then its velocity after 10 s is .....



(a) 40 m/s (b) 30 m/s

(c) 20 m/s (d) 10 m/s

9 When a body is projected vertically upwards, then during its rising .....

(a) the direction of its velocity and acceleration is upwards.

(b) the direction of its velocity is upwards and the direction of its acceleration is downwards.

(c) the direction of its velocity and acceleration is downwards.

(d) the direction of its velocity is downwards and the direction of its acceleration is upwards.

10 A ball is projected with initial velocity v_i at angle 15° to the horizontal where its horizontal range is R, then when it is projected with the same velocity at angle ..... it will reach the same horizontal range.

(a) 115° (b) 30° (c) 60° (d) 75°

Second Answer the following questions

11 Draw the relation between the velocity and the time that describes the motion of a body projected vertically upwards and returns back to its projection point. (assume that the direction of the initial velocity is negative direction)

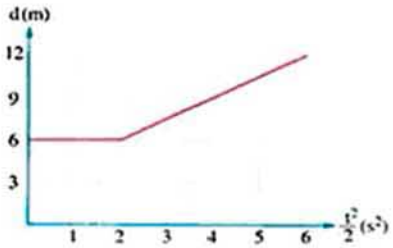
12 A stone falls freely from the top of a 100 m building and it passes by a balcony after 4 s from the instant of projection. Calculate the height of the balcony from the ground surface. ($g = 10\ m/s^2$)

.....

.....

.....

13 The opposite graph shows the relation between $(\frac{t^2}{2}, d)$ during the motion of a car. **Calculate** the acceleration of the car during its motion.



.....

.....

14 **Mention** the conditions of applying the following equation on the body's motion :

$v_f^2 = 2\,ad$

.....

.....

.....

15 A body starts its motion from rest and moves in a straight line with acceleration 2 m/s^2 to cover a distance of 100 m, then it moves with acceleration 4 m/s^2 to cover a distance of 200 m. **Calculate** the average velocity of the body.

.....

.....

.....

.....

.....

16 A body is projected horizontally from a certain height with velocity 6 m/s and at the same time from the height a body fall freely to hit the ground by velocity 8 m/s. By neglecting the air resistance, **which one** of the two bodies will reach the ground first ? **Explain your answer.** ($g = 10\ m/s^2$)

.....

.....

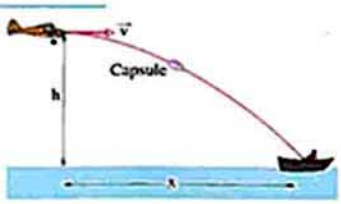
.....

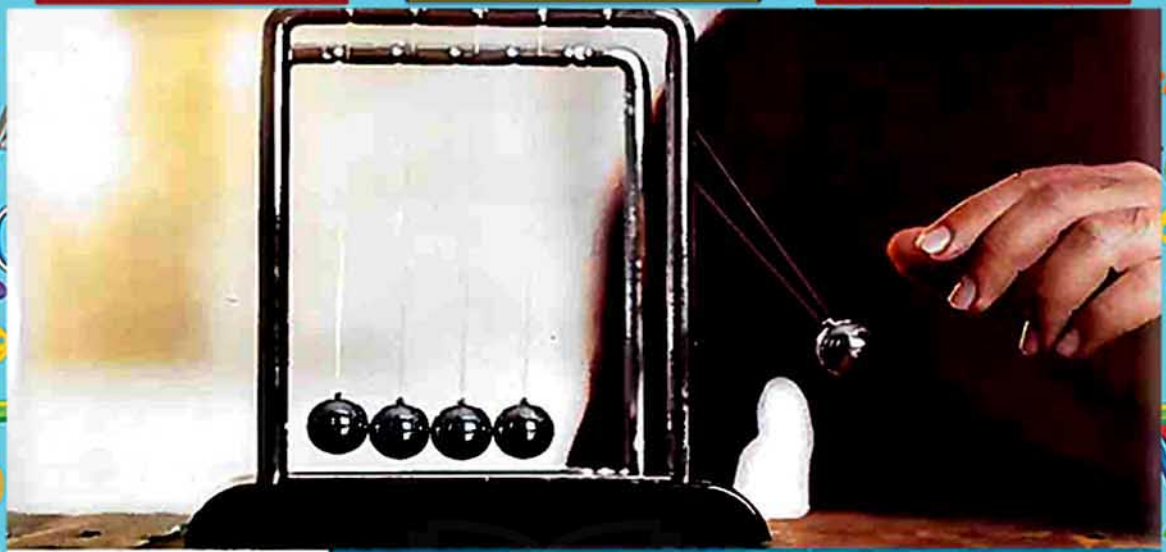
.....

.....

17 **In the opposite figure :**

A plane flies at height 500 m from the sea with velocity 55 m/s if the plane throws a capsule to a person at horizontal distance (x), **find** the value of (x).





Chapter 3 Force and Motion

We have previously described the motion of bodies by studying the concepts of velocity and acceleration without considering the causes of motion and in this chapter we will study these causes (force).

Force

Force : is an external influence that affects the object to change its state of motion or direction.

Examples :

- The force exerted by your muscles helps to pull or push things.
- The force of the car engine helps the car to start motion.
- The force of brakes acts to stop the moving car.
- The friction force created when two objects move one against the other.
- Invisible forces that work all around us like gravity, electromagnetism and nuclear force.

Distinguished Scientists

Galileo and Newton

Appreciation to Galileo and Newton for their contribution in formulating a reliable theory of motion by the end of the seventeenth century where they explored and explained motion of bodies and its causes.

Galileo

Isaac Newton

Newton's Laws of Motion

Newton has developed three laws to explain and interpret the motion of objects when a force or a group of forces affect them and we will study below each one of these laws separately.

First Newton's first law

⊙ **Explanation of Newton's first law :**

1. When a ball is placed on the floor, it remains stationary in its position unless the player acts on it and changes its state (It doesn't change its state unless acted upon by an external force).
2. When the ball is pushed on the floor, it rolls for a certain distance, then slows down till it stops by the effect of frictional forces between the ball and the floor that resist rolling (**friction** is an external force that acts to change the object state).
   If these forces do not exist, the ball would keep moving at a uniform velocity in a straight line and would not stop.


Static object keeps its state of rest unless acted upon by a resultant force.


A moving object keeps its state of motion at a uniform velocity in a straight line unless acted upon by a resultant force.

i.e. The body needs a force to change its state from rest to motion or from motion to rest but it doesn't need a force to keep its state (rest or motion with uniform velocity in a straight line).

EKB

⊙ **From the previous we can conclude Newton's first law of motion as follows :**

Newton's first law of motion :

"A static object keeps its state of rest and a moving object keeps its state of motion at a uniform velocity in a straight line unless acted upon by a resultant force".

UNIT 2

⊙ **The mathematical formula that expresses Newton's first law :**

$$\Sigma F = 0$$

The symbol (Σ) is pronounced sigma and means "resultant"

i.e. If a number of forces act on an object, they may cancel the effect of each other and their resultant equals zero. Thus, acceleration (a) = 0 and no change happens in the object's velocity either being static or dynamic.

Example

The following figures represent four static bodies, the mass of each is (m) and they are affected by several forces as shown in the following figures, which one of these bodies remains static ?

(a) *(b)* *(c)* *(d)*

Solution

Clue

In order to keep the body at rest, the resultant of forces that act on it should equal zero ($\Sigma F = 0$)

(a)	$F_x = F - F = 0$	$F_y = F$	$\therefore \Sigma F \neq 0$
(b)	$F_x = 2F - F = F$	$\therefore \Sigma F \neq 0$	
(c)	$F_y = F - F = 0$	$\therefore \Sigma F = 0$	$\therefore$ The body remains static.
(d)	$F_x = 2F - 2F = 0$	$F_y = 2F$	$\therefore \Sigma F \neq 0$

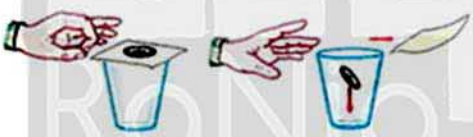
Test yourself 1

If the bodies in the previous example move with uniform velocity v, which one of them will remain moving with the same velocity ? .....

Inertia

- Newton's first law is known as the **law of inertia**.

⊙ Inertia can be clarified by the following applications :

The static object tends to keep its state of rest.	The moving object tends to keep its state of motion.
Examples	
1. Passengers in a vehicle tend to fall backwards when the vehicle suddenly moves forwards. 	1. Passengers in a vehicle tend to fall forwards when the vehicle crashes against a barrier. 
2. Fall of a coin into a cup when the card is removed rapidly. 	2. The continuity of a fan motion for a period of time when the electric current is turned off. 

Inertia :

It is the tendency of an object to keep either its state of rest or state of motion at its original velocity uniformly in a straight line.

Or

It is the property of objects to resist the change of its static or dynamic state.

Notes :

1. Newton's first law is known as the law of inertia because the object can't change its state of rest or motion in a straight line by itself.
2. Seat belt should be fastened on driving to stop inertia during sudden stop and protect passengers from being hurt.

UNIT 2

Technological Application :

- Space rockets do not consume fuel to keep moving when being out from the Earth's gravity because inertia keeps them moving at a uniform velocity in a straight line.

Test yourself

If a car moves with a uniform velocity and the driver suddenly increases its velocity, in which direction will the passengers of the car rush ?

.....

Second Newton's second law

It will be studied in the second term.

Third Newton's third law

To understand Newton's third law, we can use the following daily life observations :

1. When a person that sits on a moving chair, pushes the wall (action), the chair moves backwards (reaction).

2. When a bullet is fired (action), the rifle recoils backwards (reaction). Because of this a soldier should mount the rifle back firmly to his shoulder.

3. When blowing up a balloon and leaving it free, the trapped air pushes out the open end (action), causing the balloon to move forward (reaction).

4. When a man jumps from a boat to the reef (action), the boat shifts backwards (reaction).

⊙ Explanation of Newton's third law :

EKB

From the previous we can conclude that this law is related to two mutual forces between two different bodies. If we consider the first force (F_1) as an **action**, the second force (F_2) is considered as a **reaction** equal in magnitude and opposite in the direction.

Newton's third law of motion :

"When an object acts on another object by a force, the second object reacts with an equal force on the first object in a direction opposite to that of action".

Or

"For every action there is a reaction equal in magnitude and opposite in direction".

⊙ The mathematical formula that expresses the Newton's third law : $F_1 = -F_2$

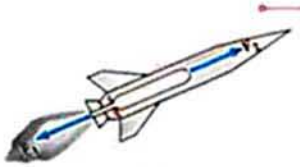
(The negative sign indicates that the two forces act in opposite directions).

Notes :

1. No single force can exist in the universe because action and reaction are paired forces; originate and vanish together.
2. Although they are equal, it is not a must that action and reaction are at equilibrium because the two forces act on different bodies and the equilibrium condition happens when the two forces act on the same body.
3. Action and reaction are of the same type; if the action is a gravitational force, reaction is a gravitational force, as well.

Technological Application :

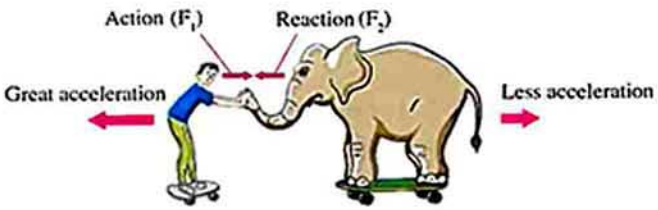
- Launching a rocket is based on Newton's third law of motion because a huge amount of burning gases rushes down the rocket to generate a reaction that pushes the rocket upwards.



UNIT 2

Example 1

Study the following figure, then answer the questions below :



(a) What is the relation between the force acting on the elephant and that on the man?

(b) Why are not action on the elephant and reaction on the man at equilibrium?

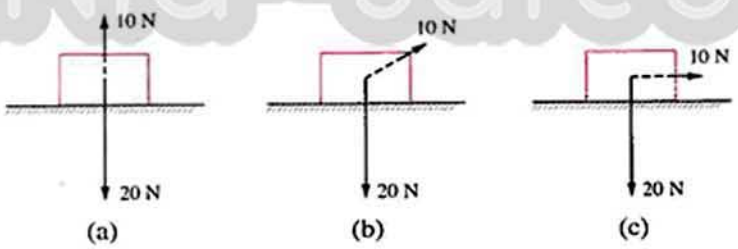
Solution

(a) The force acting on the elephant = – the force acting on the man, $F_1 = -F_2$

(b) For equilibrium to take place between two forces, they must be equal in magnitude and opposite in the direction, having one line of action and acting on the same body. All these conditions except the last one may be applied on action and reaction; since the action acts on the elephant's body and the reaction is on another body (the man).

Example 2

The following figures represent three identical boxes, the weight of each is 20 N, a force of 10 N acts on each of them, arrange the boxes in an ascending order according to the value of the reaction force that acts on the surface of the box.

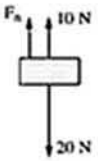


Solution

Clue

The box remains touching the surface in the three cases because the acting vertical force in the three cases is less than the weight of the box, so $\Sigma F_y = 0$ and to obtain the reaction force by which the surface acts on the box, we draw a diagram for the force vectors in each case and solve the equation $\Sigma F_y = 0$

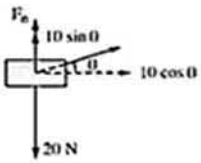
(a)



$\therefore 20 = F_n + 10$

$F_n = 20 - 10 = 10$ N

(b)

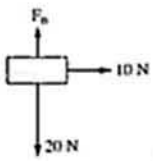


$20 = F_n + 10 \sin \theta$

$F_n = 20 - 10 \sin \theta$

$\therefore 20 > F_n > 10$

(c)



$\therefore F_n = 20$ N

$\therefore$ Box (a) < Box (b) < Box (c)

3 Test yourself

The opposite figure represents three books (x, y, z) which are placed on a table, what is the value of the resultant force that acts on the book (y) ?

.....

.....

.....

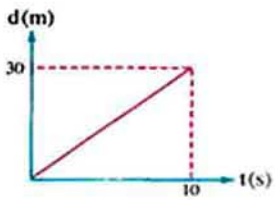
QUESTIONS ON

Chapter 3 Force and Motion

Interactive test

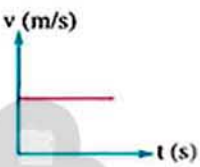
First Multiple choice questions

1. The opposite graph represents the motion of a body of mass 10 kg that moves in a straight line, so the acting resultant force on the body equals ..... .



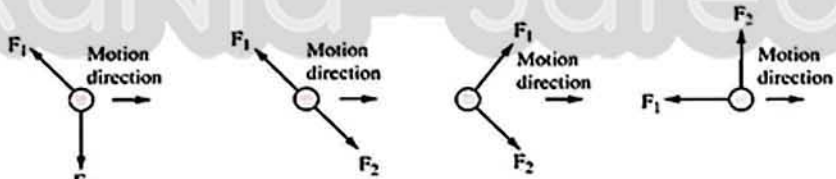
(a) 30 N (b) 300 N
(c) 3 N (d) 0

2. The opposite figure represents the motion of a body that is affected by three forces F_1 , F_2 and F_3 where the direction of each F_1 and F_2 is opposite to the direction of F_3 , so which of the following equations is correct ? ..... .



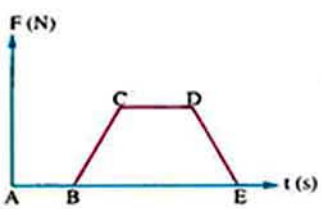
(a) $F_3 = F_1 + F_2$ (b) $F_1 = F_2 = F_3$
(c) $F_1 = F_2 + F_3$ (d) $F_2 = F_1 + F_3$

3. The following figures represent a body that moves with velocity (v) under the effect of two equal forces in magnitude F_1 and F_2 , in which of the following figures the velocity of the body doesn't change in magnitude and direction ? ..... .



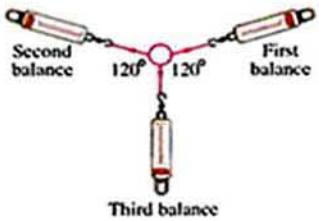
(a) (b) (c) (d)

4. The opposite graph represents the relation between the resultant force acting on a body and the time, so the time interval in which the body moves with uniform velocity is ..... .



(a) AB (b) BC
(c) CD (d) DE

5 In the opposite figure, there are three spring balances that are in equilibrium state if the reading of each of the first and the second balance is 100 N, so the reading of the third balance is ..... .



(a) 0 (b) 25 N
(c) 50 N (d) 100 N

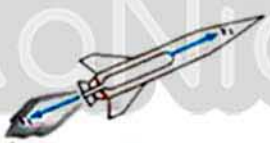
6 The continuity of rotation of the electric fan for a period of time although the electric current is turned off is due to ..... .

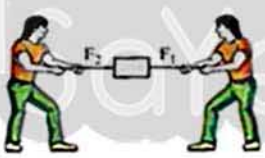
(a) inertia (b) the heavy mass of the fan blades
(c) the stored amount of electric current (d) the equilibrium of the acting forces

7 In which of the following figures, the two forces F_1 and F_2 may be in equilibrium ? ..... (knowing that : $F_1 = F_2$)


(a)


(b)


(c)


(d)

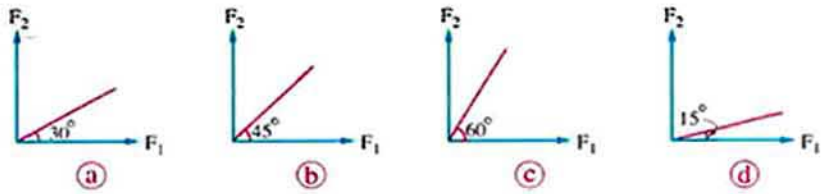
8 When blowing up a balloon and leaving it free, the balloon moves .....

(a) in the direction of the air rush
(b) in a direction right to the direction of the air rush
(c) in the opposite direction of the air rush
(d) in a direction left to the direction of the air rush

9 If the body (x) acts on the body (y) by a force of 9 N, then the reaction force of the body (y) equals .....

(a) 1 N (b) – 9 N (c) 0 (d) 9 N

10 Which of the following graphs represents the relation between the value of the action force (F_1) and the value of the reaction force (F_2) when drawn by the same drawing scale ? .....



Second Essay questions

1 **Can a body be in a state of equilibrium when it is affected by a single force ? Explain.**

2 When you are inside a plane in the night in a quiet weather, you do not feel its motion although its velocity may be 800 km/h. **Explain.**

3 **Explain the following sentences :**

(1) The bicycle continues to move for a while after stopping the paddling.

(2) Newton's first law is known as the law of inertia.

(3) The falling of passengers backwards if the car suddenly moves forwards.

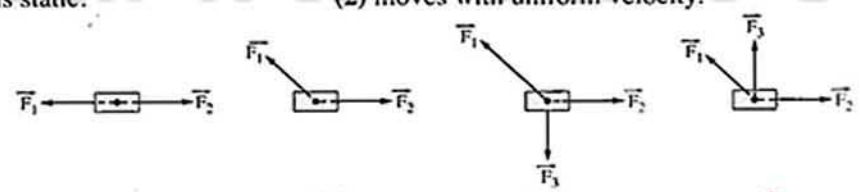
(4) • Passengers in a bus fall forwards when it stops suddenly.
• Motorcycle rider flies off the motorcycle when it hits an obstacle.

(5) A space rocket does not need to consume fuel after being moved away from the Earth's gravity.

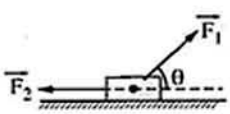
(6) The soldier mounts the back of the rifle into his shoulder cavity.

4 **In which of the following cases the body :**

(1) is static. (2) moves with uniform velocity.



5 The opposite figure represents a box which is sliding with uniform velocity on a frictionless surface under the effect of two forces, if we want to reduce the angle (θ) without changing the value of force F_1 **what** is the change that we could make on the magnitude of force (F_2) to slide down the box with the same velocity ?



6 **From the opposite figure :**

What is the physical property upon which the magician depends in doing his trick when he withdraws the mattress by keeping the cups on table ?

7 In the opposite figure **what happens when** the card is removed suddenly (rapidly) ? **And why ?**

8 **Explain why** car manufacturing companies have added safety belts to each car.

9 If a train suddenly moved forwards, **to which** direction would a bag that is placed beneath a chair move? **And why ?**

10 An astronaut projected a small object in a certain direction. **What would happen to** the astronaut as a response to his action ? Accordingly, **suggest a method** to change the direction of a spaceship outside the atmosphere.

11 **Mention the action and the reaction forces in each of the following cases :**

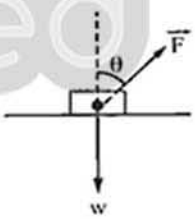
(1) A man moves in the street.

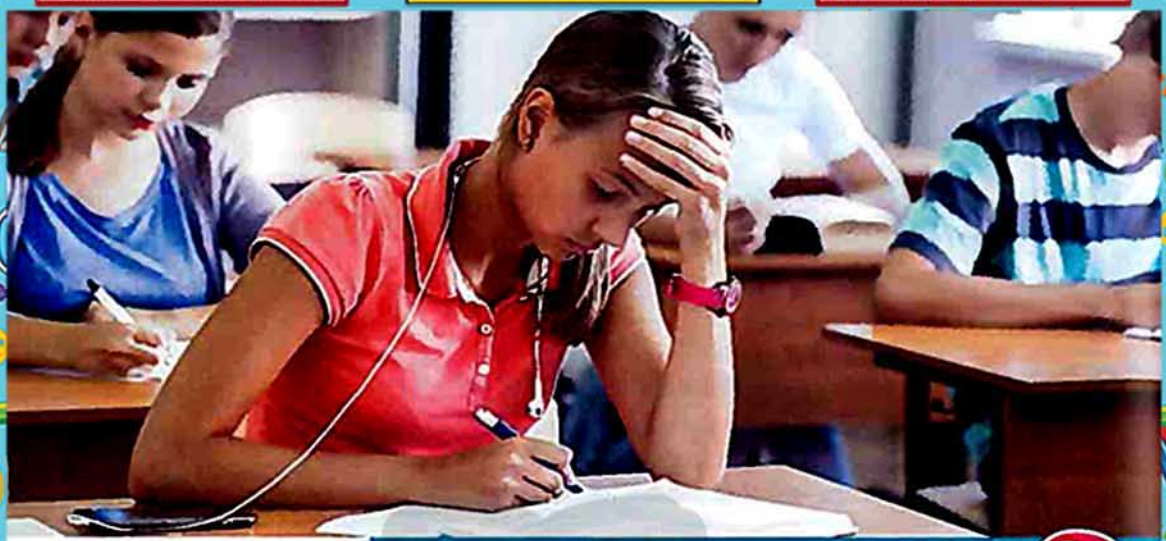
(2) A ball is thrown at the back of a girl.

(3) A goal keeper catches the football.

(4) A window is closed due to the wind blowing.

12 In the opposite figure, a force (F) acts on a body of weight (w) which is placed on a surface, **mention two methods** to increase the reaction force that acts on the body by the surface.





MODEL EXAM ON

Chapter 3

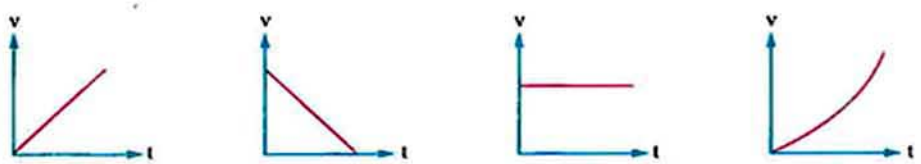
Force and Motion

First Choose the correct answer

1. If the Earth affects you by a force 600 N. So your body affect the Earth by a gravitational force of magnitude ..... .
   (a) zero (b) less than 600 N
   (c) 600 N (d) more than 600 N

2. If the resultant force acting on a moving body vanished, it means that its ..... vanished.
   (a) mass (b) velocity (c) acceleration (d) displacement

3. The graph which represents Newton's first law is ..... .

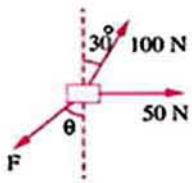


(a) (b) (c) (d)

4. A car moves on the highway with uniform velocity of 120 km/h under the effect of pushing force (F_1) as well as the frictional force (F_2), so ..... .

   (a) $F_1 = F_2$ (b) $F_2 \leq F_1$
   (c) $F_2 \geq F_1$ (d) we can't define the answer

5 In the opposite figure three forces act on a body. If the body moves at constant velocity then the angle θ equals .....



(a) 30° (b) 49.1°
(c) 59.8° (d) 60°

6 Which of the following statements doesn't apply on the action and reaction forces ? .....

(a) Action force = Reaction force
(b) Action force is opposite to reaction force
(c) Action force and reaction force are acting on the same body
(d) Action force and reaction force are acting on two different bodies

7 A ship moves towards the south with uniform velocity of 3 m/s in a straight line when the resultant force on the ship is ..... . ($g = 10\ m/s^2$)

(a) towards the north (b) towards the south
(c) equal to 30 N (d) equal to zero

8 A static book is placed on a table by a force downwards, so the reaction force for this force is ..... .

(a) the force of the Earth on the book (b) the force of the table on the book
(c) the force of the Earth on the table (d) the force of the book on the Earth

9 If a force F_1 is applied so a reaction force F_2 is initiated, the angle between F_1 and F_2 equals ..... .

(a) 60° (b) 90° (c) 180° (d) 360°

10 A metallic ball of mass 50 g was dropped into a liquid. If the ball dives in the liquid at a constant velocity of 6 m/s, the force of resistance that is produced by the liquid on the ball during it motion equals ..... . ($g = 10\ m/s^2$)

(a) 6 N (b) 0.3 N (c) 0.5 N (d) 0.083 N

Second Answer the following questions

11 Can the reaction force be vertical and its direction be downwards ?
If your answer is yes, give an example and if it is no, give reasons.

.....
.....

12 From your previous study for Newton's third law, **suggest a method** for a spacecraft to change its direction outside the atmospheric envelope.

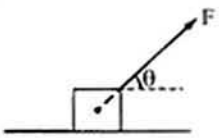
.....
.....
.....

13 A truck moves on a highway with velocity (v) and carries a free moving box which is affected by its frictional force with the car only, **what will happen to** the box if the driver applies the brakes ?

.....

.....

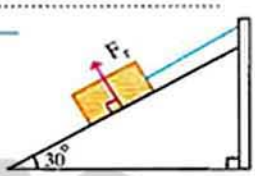
14 In the opposite figure, a force (F) affects a body which is placed on a surface, **mention two methods** to increase the reaction force which acts on the body by the surface.



.....

.....

15 In the opposite figure a box of mass 8 kg is fixed on a ramp of angle 30°.
Calculate the reaction force (F_r). (where : g = 10 m/s^2)



.....

.....

.....

16 **Which of the following cases represents :**

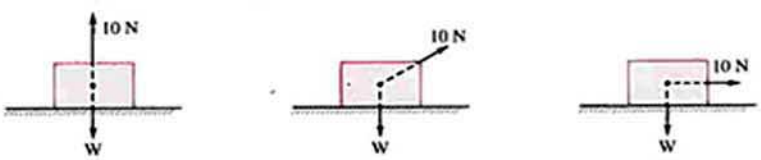
(1) a static body. (2) a moving body with uniform velocity.

(a) (b) (c) (d)

.....

.....

17 A person pulls a box on a horizontal surface by a force 10 N, **arrange** in a descending order the following cases shown on the figures according to the value of the reaction force that is acting on the box by the surface.



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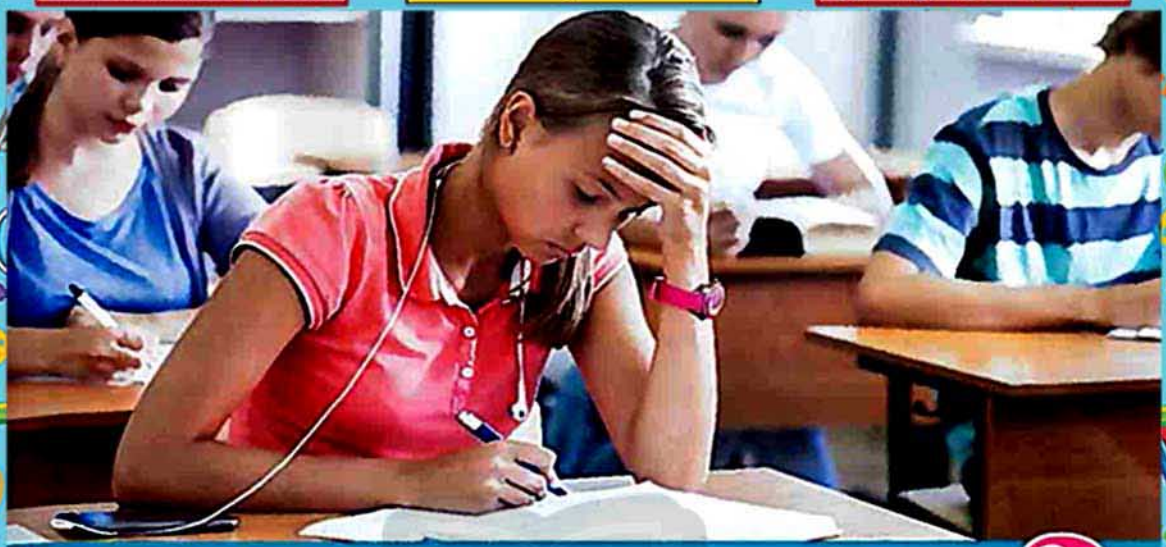


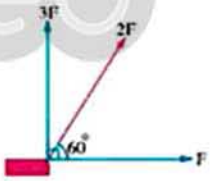
Accumulative Exam on Units 1 & 2

First Choose the correct answer

1. If the dimensional formula of X is $M^{-1}L^{2}T$ and the dimensional formula of Y is $M^{0}L^{3}T^{2}$, then the dimensional formula of $(2X - Y)$ is ..... .
   (a) $M^{-2}LT^{0}$ (b) $M^{-1}L^{2}T$ (c) $M^{0}L^{3}T^{2}$ (d) undefined

2. If the density of a body is (100 ± 10) kg/m^3 and its volume is (30 ± 3) m^3, then its mass equals ..... . (knowing that : Density = $\frac{\text{Mass}}{\text{Volume}}$)
   (a) (3000 ± 600) kg (b) (130 ± 600) kg (c) (3000 ± 30) kg (d) (130 ± 30) kg

3. From the opposite figure :
   The resultant of the three forces acting on the body is ..... .
   (a) F (b) $\sqrt{3}$ F (c) 5.13 F (d) 6 F



4. A train is moving in a straight railway where it covered one third of the distance with a speed of 25 km/h and the remaining distance was covered by a speed of 75 km/h, so the average speed of this train is ..... km/h.
   (a) 30 (b) 45 (c) 50 (d) 65

5. If the acceleration and the velocity of a body have different directions, then ..... .
   (a) the instantaneous velocity equals the average velocity
   (b) the velocity of the body increases with time
   (c) the velocity of the body decreases with time
   (d) the displacement vanishes

UNIT 2

6 An object moves from point x to point y in 20 s , where the velocity at x = 50 km/h and the velocity at y = 5.56 m/s, so the acceleration of this object is ..... .

ⓐ 1.5 km/h^2 ⓑ – 1.5 km/h^2 ⓒ 2 km/h^2 ⓓ – 2 km/h^2

7 If a stone was thrown at velocity 96 m/s into a well to reach the bottom 3 s later, then the well depth is ..... . ($g = 9.8$ m/s^2)

ⓐ 220.9 m ⓑ 332.1 m ⓒ 300.4 m ⓓ 426.2 m

8 Two identical projectiles were projected at 200 km/h , the 1st at an angle 60° to the horizontal while the 2nd one is at angle of 60° to the vertical. Which projectile reaches a greater horizontal range ? ..... .

ⓐ The 1st one ⓑ The 2nd one

ⓒ They have equal range ⓓ Not enough information to indicate which one

9 If the resultant force acting on a moving body vanishes, this means that its ..... vanishes.

ⓐ mass ⓑ velocity ⓒ acceleration ⓓ all of the previous

10 The idea of launching a rocket is based on the law of ..... .

ⓐ inertia ⓑ reaction ⓒ motion ⓓ conservation of energy

Second Answer the following questions

11 Calculate the absolute error in measuring the velocity of a body, if the relative error in measuring it is 0.06 and the actual value of the velocity is 30 m/s.

.....

12 If a body moves along the circumference of a circle, calculate the distance and the displacement covered by the body when it completes 1.75 revolutions if the radius of the circle is 2 m.

.....

.....

.....

.....

13 A body moves with uniform velocity of 4 m/s for 8 s , then it moves with uniform acceleration of 4 m/s^2 for 6 s , **calculate** the total distance covered by the body.

.....

.....

.....

.....

14 A train is moving with velocity 72 km/h. **Calculate** the time required to reach a velocity of 13 km/h , if the train is moving at deceleration of 2 m/s^2.

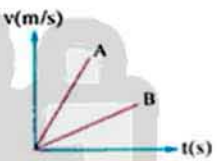
.....

.....

.....

.....

15 The opposite diagram illustrates two moving objects.



According to the graph :

(a) **Which** object has started motion from rest ?

(b) **Which** object has greater acceleration ?

.....

.....

16 A body falls from a tower so that it takes 6 s to reach the bottom , **find :**

(a) The height of the tower.

(b) The velocity at the bottom. ($g = 10\ m/s^2$)

.....

.....

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17 A projectile was projected from the ground at a velocity of 20 m/s and at an angle of 65° to the horizontal. **Calculate** the time taken by the projectile to the reach the ground.

($g = 10\ m/s^2$)

.....

.....

.....

.....

10 MODEL EXAMS

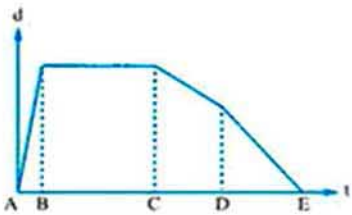
Evaluate yourself through interactive exams by scanning this QR code.

And after finishing each exam, you can view a detailed report of your answers to evaluate yourself.

Model Exam 1

First Multiple choice questions

1. The opposite graph represents the relation between the displacement (d) and the time (t) for a car that moves in a straight line, so in which period the velocity of the car is greatest ? ..... .



(a) Period AB
(b) Period BC
(c) Period CD
(d) Period DE

2. A man stands on the edge of a rocky cliff that overlooks a lake. He projects two identical balls A and B with the same velocity. If A is projected upwards and B is projected downwards, so which of them will reach the water's surface at higher velocity ? ..... .

(a) The ball A
(b) The ball B
(c) Both of them reach the water's surface with the same velocity
(d) No correct answer

3. cm = ... micrometer

(a) 10^2 (b) 10^4 (c) 10^6 (d) 10^8

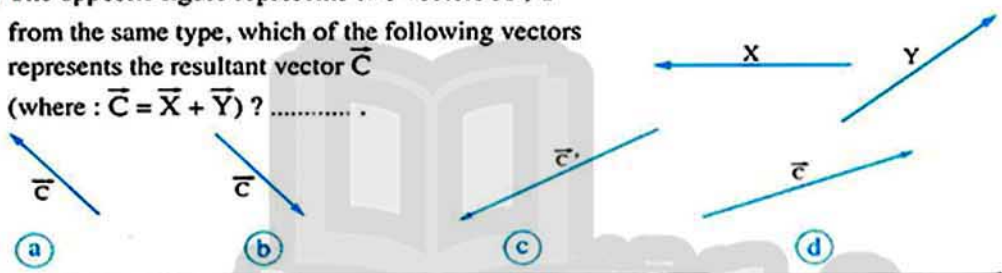
4. An airport runway is designed for a particular type of airplanes, if the speed of the airplane should reach at least 126 km/h before taking off and it was moving with acceleration 3.5 m/s^2, so the length of the airport runway should be at least ..... .

(a) 125 m (b) 150 m (c) 175 m (d) 225 m

(5) When a horse pulls a cart, the force which causes the movement of the horse forward is ..... .

(a) the force by which the horse affects the cart
(b) the force by which the cart affects the horse
(c) the force by which the Earth affects the cart
(d) the force by which the Earth affects the horse

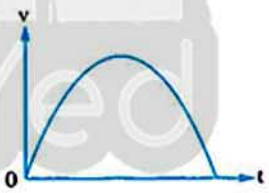
(6) The opposite figure represents two vectors $\overline{X}$, $\overline{Y}$ from the same type, which of the following vectors represents the resultant vector $\overline{C}$ (where : $\overline{C} = \overline{X} + \overline{Y}$) ? ..... .

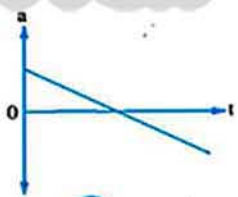


(7) A body is projected with velocity (v) at angle 30° to the horizontal and has a horizontal range of 50 m, if the body is projected with the same velocity and at angle 60° to the horizontal, so its horizontal range will be ..... .

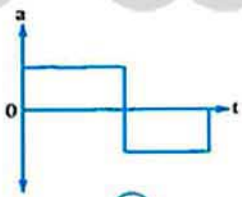
(a) 25 m (b) 43 m (c) 50 m (d) 100 m

(8) The opposite graph represents the change in the velocity (v) of a body that moves in a straight line with the time (t), which graph of the following graphs represents the change in the acceleration (a) of this body with the time (t) ? ..... .

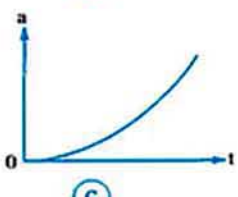




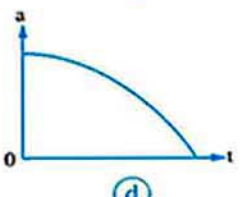
(a)



(b)



(c)



(d)

9 If the dimensional formula of the quantity (x) is LT^{-1} and the dimensional formula of the quantity (y) is ML^{-1}, so the dimensional formula of the quantity (z) that verifies the equation : $x = \sqrt{\frac{z}{y}}$ is ..... .

(a) MLT^{-1} (b) MLT^{-2} (c) ML^2T (d) MLT

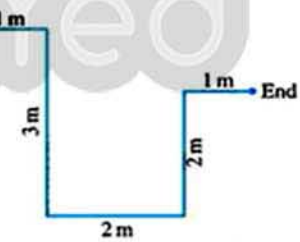
10 If a car covers 40 km towards the south during 1.5 h, then it changes its direction and moves 30 km towards the east during 0.5 h, so the average velocity of the car equals ..... .

(a) 5 km/h (b) 15 km/h (c) 25 km/h (d) 35 km/h

Second Answer the following questions

11 Two balls (A and B) were projected in the air, where ball (A) was projected at angle to the horizontal greater than the angle by which the ball (B) was projected. If the maximum height reached by the two balls is the same, which of them has the larger time of flight? Explain your answer.

12 The opposite figure represents the path of a moving body, calculate the value of the total displacement covered by the body ?



13 What happens to a group of boxes that are placed on the top of a car and are not strapped when the car starts its motion suddenly and stops suddenly?

14 **When does** the direction of the body's acceleration by which the body moves be opposite to the direction of its motion?

15 A railway worker stands 180 m away from the starting point of a train whose length is 95 m which begins its motion from the rest by a uniform acceleration, if the speed of the front of the train when it passes by the worker is 25 m/s, what is the speed of the back of the train when it passes by the worker ?

16 The radius of a circle is measured and it was found to be (10.5 ± 0.2) m, calculate the area of the circle. (knowing that : the area of the circle $= \pi r^2$)

17 A ball is projected vertically downwards with velocity (v) from a height of 4 m, then it reached the Earth's surface during a time that equals half the time taken by it when it is left to fall freely from the same height, **calculate** the value of (v). ($g = 10$ m/s^2)

Model Exam 2

First Multiple choice questions

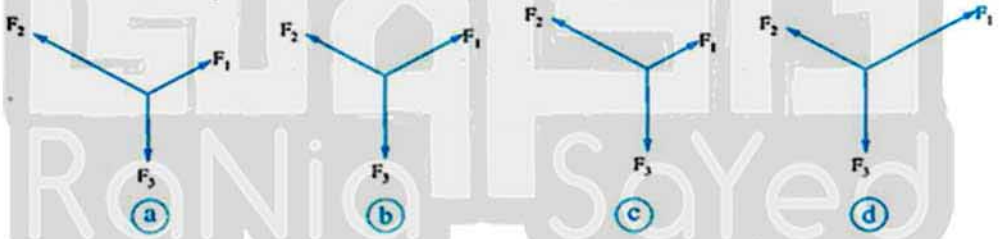
1. A body moves according to the relation $d = 40\,t - 2\,t^2$, so its initial velocity and acceleration equal ..... , ... respectively.

(a) 40 m/s , – 2 m/s^2 (b) 2 m/s , – 40 m/s^2
(c) 20 m/s , – 1 m/s^2 (d) 40 m/s , – 4 m/s^2

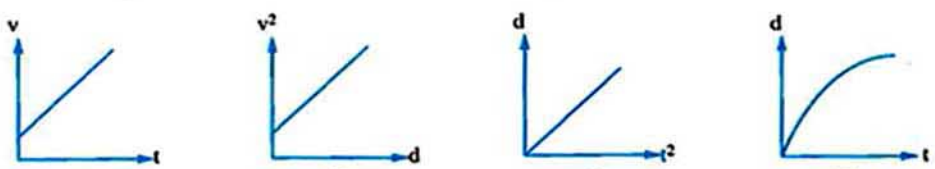
2. When measuring the volume of a liquid using a graduated cylinder, the absolute error was 0.6 cm^3 and the relative error was 1.2 % , so the actual value of volume of the liquid is ..... .

(a) 18 cm^3 (b) 50 cm^3 (c) 60 cm^3 (d) 120 cm^3

3. A body moves with constant velocity under the effect of three forces F_1 , F_2 and F_3 that have equal angles between them, which of the following figures represents the forces that act on the body ? ..... .



4. Which of the following figures represents a body that starts its motion with initial velocity that doesn't equal to zero and moves with a uniform positive acceleration ? ..... .



(a) Figure (1) only (b) Figure (2) only
(c) Figures (1) and (2) (d) Figures (3) and (4)

5 If the dimensional formula of the physical quantity (A) is $M^2 LT^{-2}$ and the dimensional formula of the physical quantity (B) is $M^2 LT^{-2}$, so the dimensional formula of the quantity (4 A – 2 B) is ..... .

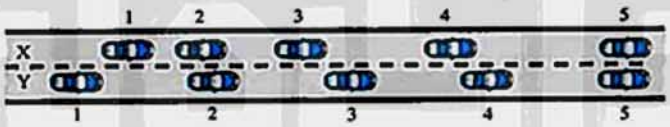
(a) $M^4 L^2 T^{-4}$ (b) $M^{-4} L^{-2} T^4$

(c) $M^2 LT^{-2}$ (d) has no physical meaning

6 A car moves with velocity 30 m/s, its driver applies the brakes and the car is affected by a negative acceleration of 6 m/s^2, so the ratio between the velocity of the car after a period of 1 s to its velocity after a period of 2 s is ..... .

(a) $\frac{1}{2}$ (b) $\frac{2}{3}$ (c) $\frac{3}{2}$ (d) $\frac{4}{3}$

7 The next figure represents the positions of the two cars X and Y at consecutive intervals of time where the magnitude of each interval is 1 s and the direction of the two cars was to the right.



Which of the following statements correctly describe the motion of the two cars ? ..... .

(a) The two cars move with non-uniform velocity

(b) The car (X) moves with uniform velocity, while the car (Y) moves with uniform acceleration

(c) The car (X) moves with negative uniform acceleration, while car (Y) moves with uniform velocity

(d) The car (X) moves with uniform positive acceleration, while the car (Y) moves with uniform velocity

8 A body is projected upwards at angle (θ) to the horizontal, if the horizontal range reached by the body equals the maximum vertical height reached by it, then the value of the angle (θ) is approximately ..... .

(a) 45° (b) 60° (c) 76° (d) 90°

9 A group of students measure the velocity of a moving body, which of these measurements is more accurate ? ..... .

(a) (350 ± 20) m/s (b) (340 ± 15) m/s (c) (335 ± 10) m/s (d) (320 ± 10) m/s

10 A train was moving with uniform velocity of 108 km/h and when the driver applies the brakes, the train stops after 15 s, so the uniform acceleration by which the train moves from the moment of using the brakes is ..... .

(a) $-2\ m/s^2$ (b) $-1.2\ m/s^2$ (c) $-0.4\ m/s^2$ (d) $-7.2\ m/s^2$

Second Answer the following questions

11 A ball is projected vertically upwards where it took 3 s to reach the maximum height, calculate the maximum height reached by the ball. ($g = 10\ m/s^2$)

12 A man moves in a straight line away from a building a distance of 100 m then he stops for 40 s then he completes his motion in the same direction to cover a distance of 0.5 km, so what is the position of the man away from the building ?

13 Two trucks move in two parallel lines and in two opposite directions with the same velocity which equals 90 km/h, if the distance between them is 8.5 km, when will the two trucks meet ?

14 "If a body moves with uniform velocity, its acceleration equals zero". **Explain.**

15 The image illustrates a player in a boat race :

(a) **Extract** a pair of forces in this situation that represents action and reaction.

(b) **Show how** the boat can reach a greater speed.

16 Vector A has vertical and horizontal components 3.2 and 1.6 respectively and vector B has vertical and horizontal components 0.5 and 4.5 respectively, **find** the angle between the two vectors $\overline{A}$ and $\overline{B}$.

17 The opposite figure shows a tennis player that hits a ball horizontally at a height of 2.5 m from the ground,

calculate : ($g = 10\ m/s^2$)

(a) The speed of projecting the ball that makes it barely exceed the net that rises 0.9 m from the surface of the ground which is located away from the player a horizontal distance of 15 m.

(b) The horizontal range of the ball if it is projected by its velocity in (a).

Model Exam 3

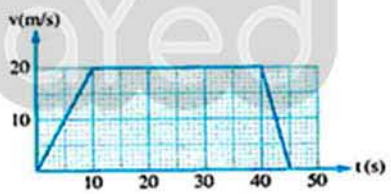
First Multiple choice questions

1. A boat moves towards the east with velocity of 20 m/s, then it is affected by acceleration towards the west of 4 m/s^2, so its displacement after 15 s from the moment at which the boat starts to acquire the acceleration, equals ..... .
   (a) 350 m towards the east. (b) 300 m towards the west.
   (c) 750 m towards the east. (d) 150 m towards the west.

2. The scalar product of two vectors and the magnitude of their vector product equalize when the angle between the two vectors is ..... .
   (a) 75° (b) 60° (c) 45° (d) 30°

3. A bullet moves with velocity 220 m/s to hit a tree and penetrates it a distance of 4.33 cm until it stops, so the average acceleration of the bullet inside the tree is ..... .
   (a) -5.59×10^3 m/s^2 (b) -3.14×10^6 m/s^2
   (c) -5.59×10^5 m/s^2 (d) -2.54×10^3 m/s^2

4. The opposite figure represents the relation between the velocity of a body that starts its motion from the rest and its time of motion, then the total displacement covered by the body through 45 s equals ..... .



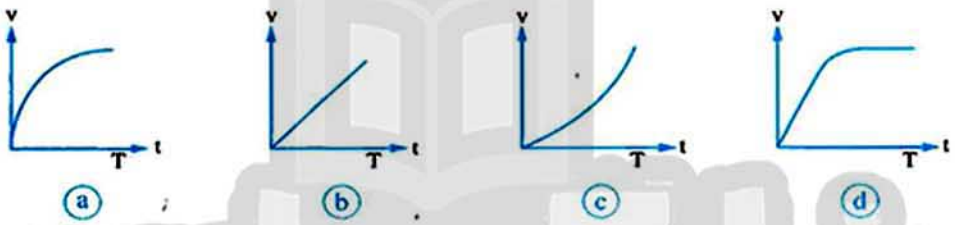
   (a) 300 m (b) 350 m (c) 450 m (d) 750 m

5. A man starts his motion from the rest and moves in a straight line with uniform acceleration, if his average velocity during 20 s is 2 m/s, then his instantaneous velocity after 25 s from his starting point is ..... .
   (a) 2.5 m/s (b) 5 m/s (c) 7.5 m/s (d) 10 m/s

6 If the length of a student is (1.8 ± 0.05) m and the length of another student is (1.95 ± 0.05) m, so the second student is longer than the first student by ..... .

(a) (3.75 ± 0.05) m
(b) (3.75 ± 0.1) m
(c) (0.15 ± 0.1) m
(d) (0.15 ± 0.05) m

7 A body falls freely from the top of a building and reached the ground after time (T), if the resistance of air is neglected, which of the following figures represents the change of its velocity with time ? ..... .

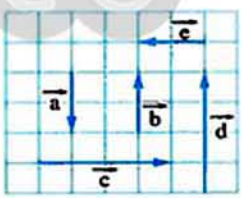


(a) (b) (c) (d)

8 A student carries a ball in her hand if the force that acts on the ball by the Earth is the action force, so the reaction force is the force that acts on ..... .

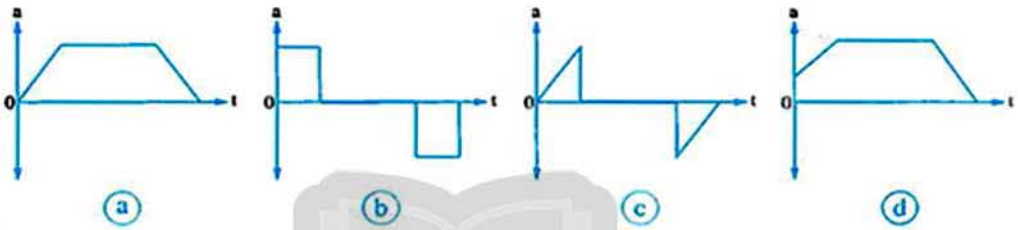
(a) the Earth by the ball.
(b) the hand by the ball.
(c) the ball by the hand.
(d) the hand by the Earth.

9 From the opposite diagram, which of the following relations is correct ? .....



(a) $\vec{a} = \vec{b}$
(b) $\vec{a} = -\vec{b}$
(c) $\vec{e} = \frac{1}{2}\vec{c}$
(d) $\vec{a} = \frac{1}{2}\vec{d}$

10 A car starts its motion from rest and moves with uniform acceleration until its velocity reaches (v) then it continues its motion with uniform velocity for a period before the driver applies the brakes to decrease its velocity uniformly till it stops, which of the following graphs describes the motion of the car accurately ? ..... .

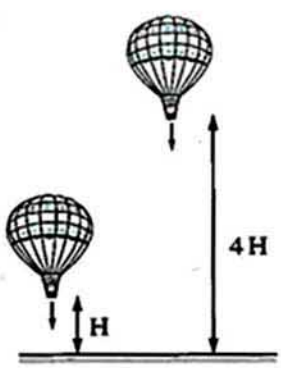


Second Answer the following questions

11 A group of students measured the density of a liquid several times then they calculate the average of their readings. **Explain** why the students calculate the average of their readings.

12 If the two balls A and B rolled on the surface of smooth horizontal table with velocities v and 2 v respectively then they fall from the surface of the table at the same time, which of them will hit the ground first ?

13 Two boxes are dropped from a balloon, the first one is dropped when the distance between the balloon and the Earth's surface was (H) and the second one when the distance was (4 H), **calculate** the ratio between the time taken by the box to reach the Earth's surface in the second case and the time taken by it in the first case.



14 Two cars move on a desert road as in figure (1) and after 5 s the two cars became adjacent at the second light pole as in figure (2), if the distance between each two successive light poles is 70 m, what is the average velocity of the two cars A and B during the first five seconds shown in the two figures.

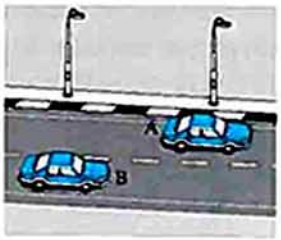


Figure (1)

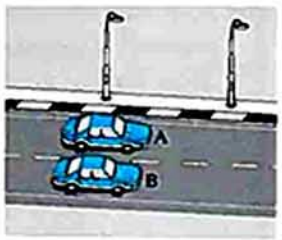


Figure (2)

15 A body is projected from the Earth's surface at angle (θ) to the horizontal where its horizontal range is 240 m and its maximum height is 45 m, calculate the value of (θ).

($g = 10\ m/s^2$)

16 In an experiment to find the velocity of sound in the air by using closed tubes, if you know that the relation between the frequency of the sound wave in the tube (f) and the length of tube (ℓ) is $f = \frac{1}{4} v\ell^n$ by neglecting the effect of the radius of the tube, find the value of the constant (n) using the dimensional formula knowing that the frequency is measured in hertz ($hz = s^{-1}$).

17 In the next two figures, there's a child sitting on a swing where in figure (1) the ropes of the swing are vertical and in figure (2) the ropes of the swing are inclined :

Figure (1)

Figure (2)

(a) **Explain why the tension force in each rope is 100 N in figure (1) ?**

(b) **Choose :**

In figure (2) : What happens to the tension force (F) in each rope ? ..... .

(a) Remains 100 N (b) More than 100 N (c) Less than 100 N

Model Exam 4

First Multiple choice questions

1 A body is moving according to the relation : $v_f = 2t$, then its displacement after 5 s equals ..... .

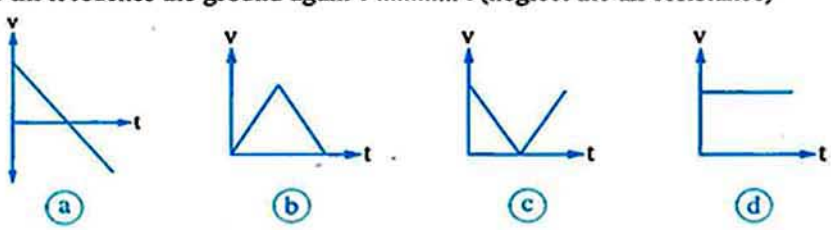
(a) 10 m (b) 15 m (c) 20 m (d) 25 m

2 When the density of a liquid is measured by a hydrometer, it is found to be $(10^3 \pm 1)$ kg/m^3. So, ...

	The type of measurement	The percentage of error in measurement
(a)	Direct	0.1 %
(b)	Direct	1 %
(c)	Indirect .	0.1 %
(d)	Indirect	1 %

3 Which of the following bodies is in equilibrium ? ..... .

4 If a body is projected from the ground at angle θ to the horizontal, which graph of the following graphs represents the change of the body's vertical velocity with the time till it reaches the ground again ? ..... . (neglect the air resistance)



5 The motion of the Moon in its path around the Earth when it is observed during a whole night is considered ..... motion in a ..... .

(a) periodic, straight line
(b) vibrational, curved path
(c) translational, straight line
(d) translational, curved path

6 The most accurate tool for measuring the time taken by an object to fall from the top of a building is ..... .


(a)


(b)

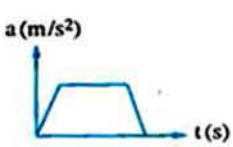

(c)

(d)

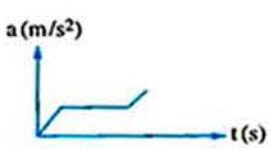
7 A car moves from rest with uniform acceleration of 6 m/s^2, so the ratio between the distance moved by the car during the first second and the distance moved by it during the third second is .....

(a) $\frac{2}{3}$ (b) $\frac{1}{5}$ (c) $\frac{4}{9}$ (d) $\frac{9}{16}$

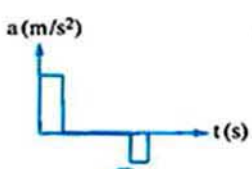
8 The opposite (velocity - time) graph describes the motion of a car, so the (acceleration - time) graph that represents the motion of the car is ..... .



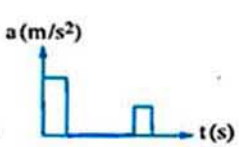
(a)



(b)



(c)



(d)

(9) A ball is projected horizontally with velocity v from the roof of a building and at the same time another ball falls freely from the same height. Neglecting the air resistance, which of the following statements is right ? ..... .

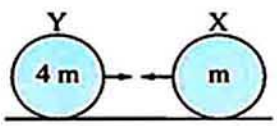
(a) The first ball reaches the ground first

(b) The second ball reaches the ground first

(c) The two balls reach the ground at the same time, where the velocity of the first ball is greater than that of the second ball

(d) The two balls reach the ground at the same time, where the velocity of the second ball is greater than that of the first ball

(10) The opposite figure shows the collision of the two bodies X and Y which have masses of m and 4 m respectively. If the body X acts on the body Y during the collision by force F, then the body Y acts on the body X by force ..... .



(a) F (b) $\frac{1}{4}$ F (c) 4 F (d) – F

Second Answer the following questions

(11) Assume that the displacement (d) of a body is related with time (t) as in the given relation : $d = ct^2$

Find the dimensional formula of c.

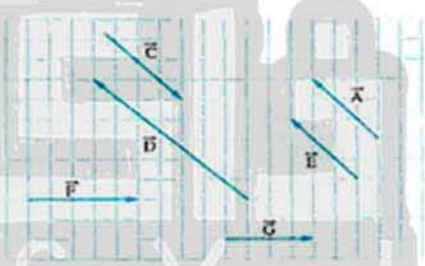
(12) A football player kicks a ball from the ground with velocity 18 m/s at an angle of 35° to the horizontal, **calculate** the time taken by the ball to reach the ground again. ($g = 10\ m/s^2$)

(13) A car covered a distance of 20 km in the west direction during 0.5 h, then it changes its direction to cover 20 km in the east direction during 0.5 h. **Calculate** the average speed of the car during its journey.

14 The displacement covered by a body was measured to be (6 ± 0.05) m and the time taken by the body to cover this displacement was measured to be (10 ± 0.1) s, calculate the velocity of the body.

15 A rock falls freely from the top of a building of height 122.5 m. If the free fall acceleration equals 9.8 m/s^2, calculate the rock's velocity before it reaches the ground by one second.

16 Using the opposite figure, which of the following vectors are equal and which of them are unequal ? ..... .



(a) The two vectors $\vec{A}$ and $\vec{E}$

(b) The two vectors $\vec{A}$ and $\vec{C}$

(c) The two vectors $\vec{G}$ and $\vec{F}$

(d) The two vectors $\vec{E}$ and $\vec{D}$

17 A stone is projected vertically upwards with velocity 18 m/s from the ground. When will it reach a height of 11 m : ($g = 10$ m/s^2)

(a) during its ascending. (b) during its descending.

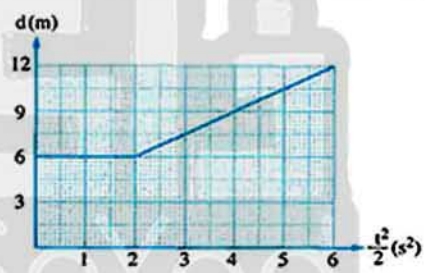
Model Exam 5

First Multiple choice questions

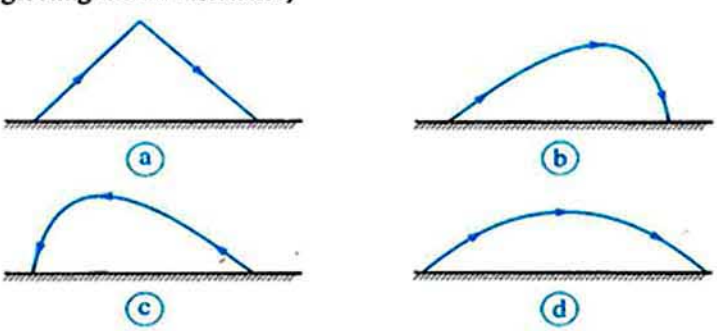
1. The body is in equilibrium when ..... .
   (a) the resultant of the forces that acts on it equals zero
   (b) it is static
   (c) it is moving with constant velocity in a straight line
   (d) all the previous

2. When a body falls freely, the ratio between its displacement after time of 1 s and its displacement after time of 2 s and its displacement after time of 3 s is ..... .
   (neglecting the air resistance)
   (a) 1 : 2 : 3 (b) 1 : 2 : 4 (c) 1 : 3 : 5 (d) 1 : 4 : 9

3. The opposite graph shows the $\left(d - \frac{t^2}{2}\right)$ curve for a car, so the acceleration equals ..... .
   (a) 6 m/s^2
   (b) 2 m/s^2
   (c) 1.5 m/s^2
   (d) 3 m/s^2



4. A boy projects a rock at angle to the horizontal, which graph of the following graphs represents the motion of the rock from the point of projection till it reaches the ground ? ..... . (neglecting the air resistance)



5 A body moves in a straight line where its displacement (x) changes with time (t) according to this relation : $x = Bt + Ct^2$, then ..... .

	The dimensional formula of B	The dimensional formula of C
(a)	L	L^2
(b)	L	T^2
(c)	LT^{-1}	L^2
(d)	LT^{-1}	LT^{-2}

6 A stone is projected vertically upwards from the ground to reach its maximum height h after time of 3 s, so the value of h is ..... . ($g = 10\ m/s^2$)

(a) 60 m (b) 45 m (c) 30 m (d) 15 m

7 A racer accelerates his car from rest to 180 km/h during 4 s , so it will cover a displacement of ..... during 3 s.

(a) 180 m (b) 12 m (c) 186.45 m (d) 56.25 m

8 If the meter equals 3.281 feet, then the volume of a cube of side length 1.5 feet is ..... .

(a) $46 \times 10^{-2}\ m^3$ (b) $119.2\ m^3$
(c) $4.9\ m^3$ (d) $9.6 \times 10^{-2}\ m^3$

9 If the Earth acts on you when you are moving by 600 N, then your body acts on the Earth by force of ..... .

(a) zero (b) 300 N (c) 600 N (d) 1200 N

10 The most accurate measurement of the motion time of a body from the following measurements is ..... .

(a) (3 ± 0.5) ms (b) (3.2 ± 0.5) ms
(c) (2.5 ± 0.025) ms (d) (2.5 ± 0.25) ms

Second Answer the following questions

11 **Can** we apply the equations of motion with uniform acceleration on a body that moves with zero acceleration ? **Explain your answer.**

12 **Can** the motion of a car be in the east direction, if the car is affected by an acceleration in the west direction at the same time ? **Explain your answer.**

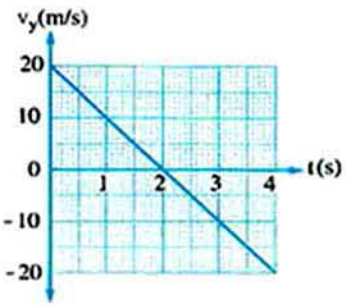
13 A car is moving by a velocity of 50 m/s, at a certain instant the driver applies the brakes, so the car's velocity decreases till it reaches 30 m/s during a distance of 160 m. If the deceleration of the car was uniform, **calculate** the distance covered by the car from the instant of applying the brakes till it stops.

14 When the density of a cube was calculated, the percentage of error in measuring its mass was 2 % and the percentage of error in measuring its side length was 0.5 %. **Calculate** the percentage of error in calculating its density. (knowing that : Density = $\frac{\text{Mass}}{\text{Volume}}$)

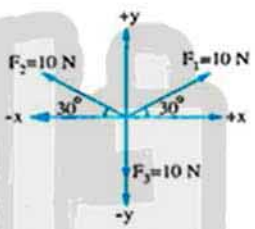
15 The opposite graph shows the change of the vertical component of the velocity of a body that is projected at an angle of 37° to the horizontal with the time, **calculate :**

(a) The horizontal range of the body.

(b) The velocity of the body at height of 15 m during its descending.



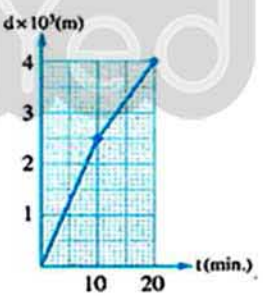
16 The opposite figure shows three forces acting on a particle, **find** the resultant of these forces and its direction.



17 The opposite graph shows the relation between the displacement covered by a runner and the time taken by him. **Calculate** the average velocity of the runner during the following time intervals :

(a) From t = 0 to t = 10 minutes

(b) From t = 10 to t = 20 minutes



Model Exam 6

First Multiple choice questions

1. A bicycle is moving with a positive uniform acceleration of 3 m/s^2, if it started motion with an initial velocity of 5 m/s, then after a displacement of 12.5 m its velocity becomes ..... .

(a) 2 m/s (b) 8 m/s (c) 10 m/s (d) 12 m/s

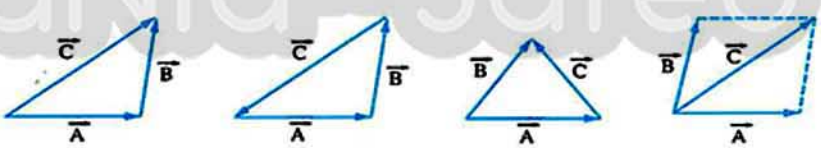
2. The dimensions of a metallic medal is measured and found to be 22.3 mm, 4.35 mm and 12.7 mm, which of the following tools is used to measure them ? ..... .

(a) A plastic ruler (b) The standard meter
(c) The meter tape (d) The vernier caliper

3. An object started motion from rest at a uniform acceleration, if its average velocity within time t was 5 m/s, then within time 3 t its velocity becomes ..... .

(a) 5 m/s (b) 15 m/s (c) 25 m/s (d) 35 m/s

4. Which of the following figures represents the resultant vector $\vec{C}$ for the vectors $\vec{A}$ and $\vec{B}$? ..... .



(1) (2) (3) (4)

(a) Figures (1) and (2) (b) Figures (3) and (4)
(c) Figures (1) and (4) (d) Figures (2) and (3)

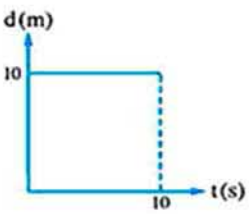
5. An object is moving in a straight line according to the relation : $v_f = \sqrt{49 + 6d}$, then the object is moving with acceleration of ..... .

(a) 2 m/s^2 (b) $\sqrt{6}$ m/s^2 (c) 3 m/s^2 (d) 6 m/s^2

6 A metallic ball of radius r is dropped into a tank of water, if its velocity in water was v and affected by a resistance force given by the relation F = Krv where K is constant, then the measuring unit of K is ..... .

(a) $kg.m^2.s^{-1}$ (b) $kg.m^{-2}.s^{-2}$ (c) $kg.m^{-1}.s^{-1}$ (d) $kg.m.s^{-2}$

7 The opposite figure illustrates the (displacement - time) graph for an object of mass 2 kg, so the resultant force acting on it is ..... .



(a) 100 N (b) 200 N

(c) 102 N (d) 0

8 The opposite figure illustrates an object that slides on an inclined smooth surface, which of the following statements describes the objects motion correctly ? .....

(a) Both velocity and acceleration increase

(b) The velocity increases but the acceleration remains constant

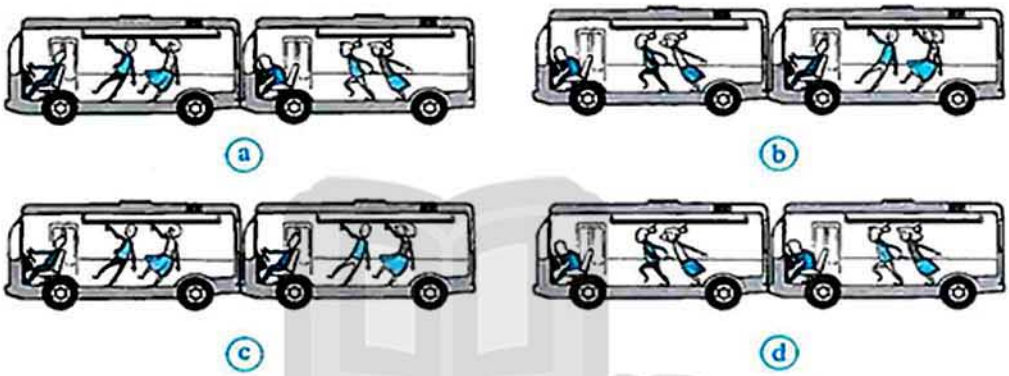
(c) The velocity remains constant and the acceleration equals zero

(d) Both the velocity and the acceleration are constant

9 An object is projected vertically upwards, so its velocity at a vertical height of $\frac{h}{4}$ was 18 m/s where h is the maximum height reached by the object, then the value of h is ..... ($g = 10\ m/s^2$)

(a) 28.7 m (b) 21.6 m (c) 15 m (d) 7.5 m

(10) A bus was standing in a traffic light when another bus collided it suddenly from behind. Which of the following figures represents the movement of the passengers in the two buses at the moment of collision ? .....



Second Answer the following questions

(11) The opposite graph represents the relation between the displacement (d) which is made by an object that is moving in a circular path from a point on its path and the distance covered by it (s). **Calculate** the diameter of the circular path.

(12) **What** are the velocity and acceleration of a projectile that is projected upwards with velocity v_i at an angle θ to the horizontal when it reaches its maximum height ?

(13) A car is moving with a speed of 88 km/h behind a truck that is moving with a velocity of 75 km/h and at a distance of 110 m from the car. **Calculate** the time required by the car to reach the truck.

14 A car spent three hours during its trip in a straight line. If it covered 100 km through the first two hours and 80 km through the third hour, **calculate** the average velocity of the car during this trip.

15 **Prove that** the ratio between the covered distance within the first second and the covered distance within the second second and the covered distance within the third second for a free falling body is (1 : 3 : 5) respectively considering the air resistance is negligible.

16 A ball is projected horizontally with a speed of 6 m/s from the edge of a horizontal table at a height of 0.8 from the ground, **calculate** :

(a) The distance between the impact point of the ball with the ground and the edge of the table.

(b) The speed of impact of the ball with the ground. ($g = 10\ m/s^2$)

17 An object starts its motion from rest in a straight line with a uniform acceleration (a) and makes a displacement (d) in time (t). If $d = (200 \pm 0.5)$ m and $t = (20 \pm 0.5)$ s, **calculate** the acceleration of the object.

Model Exam 7

First Multiple choice questions

1. Two vectors $\vec{A}$ and $\vec{B}$ are equal in magnitude and perpendicular on each other, then the operation that makes their product .....

	Maximum	Zero
(a)	$\vec{A} \cdot \vec{B}$	$\vec{A} - \vec{B}$
(b)	$\vec{A} \cdot \vec{B}$	$\vec{A} \wedge \vec{B}$
(c)	$\vec{A} \wedge \vec{B}$	$\vec{A} - \vec{B}$
(d)	$\vec{A} \wedge \vec{B}$	$\vec{A} \cdot \vec{B}$

2. If an object is projected with a velocity v_i at an angle θ to the horizontal, then its horizontal range when it comes back to the same projection plane can be calculated from the relation : .....

(a) $R = \frac{-v_i^2 \sin\theta \cos\theta}{2g}$ (b) $R = \frac{-v_i^2 \sin\theta \cos\theta}{g}$

(c) $R = \frac{-2 v_i \sin\theta \cos\theta}{g}$ (d) $R = \frac{-2 v_i^2 \sin\theta \cos\theta}{g}$

3. The projectiles motion is considered a motion in two dimensions, one is horizontal and the other is vertical, which of the following statements can describe the projectile's motion correctly ? ..... .

(a) The speed in the horizontal dimension is variable and the acceleration in the vertical dimension is variable

(b) The speed in the horizontal dimension is constant and the acceleration in the vertical dimension is variable

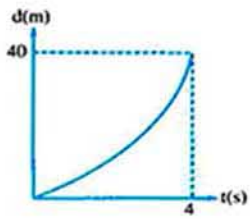
(c) The speed in the horizontal dimension is variable and the acceleration in the vertical dimension is constant

(d) The speed in the horizontal dimension is constant and the acceleration in the vertical dimension is constant

4 A man tried to push a box of mass 40 kg on a rough horizontal surface but he couldn't, so the net force acting on the box is ..... .

(a) 0 (b) 40 N (c) 400 N (d) 4000 N

5 The opposite graph illustrates the motion of an object started its motion from rest with a uniform acceleration, so the acceleration of its motion is ..... .

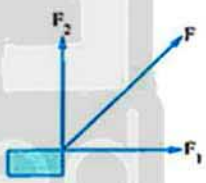


(a) 5 m/s^2 (b) 10 m/s^2
(c) 40 m/s^2 (d) 2.5 m/s^2

6 A train of length 100 m is moving with an acceleration of 1 m/s^2 entered a straight tunnel of length 1.3 km with a speed of 3 m/s, so the required time for the entire train to get out from the tunnel is ..... .

(a) 300 s (b) 75 s (c) 50 s (d) 20 s

7 In the opposite figure, an object is acted upon by two perpendicular forces F_1 and F_2, so their resultant force (F) is ..... .



(a) equal to $F_1 + F_2$
(b) less than $F_1 + F_2$
(c) greater than $F_1 + F_2$
(d) equal to $F_1 - F_2$

8 If the two physical quantities A and B have different dimensional formula, which of the following mathematical operations has a physical meaning ? .....

(a) $A + B$ (b) $A - B$ (c) $A - \frac{A}{B}$ (d) AB

9 A man at rest started his motion in a straight line till his velocity reached 4 m/s within a time of 8 s, so the acceleration of his motion equals ..... .

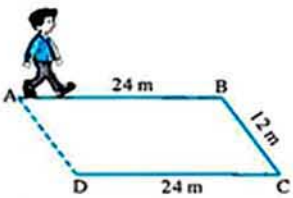
(a) 0.5 m/s^2 (b) 1 m/s^2 (c) 2 m/s^2 (d) 4 m/s^2

(10) A student measured the dimensions of a garden of area 200 m^2, if the relative error in measuring this area was 0.05, then the absolute error for that measurement is ..... .

(a) 5 m^2 (b) 10 m^2 (c) 15 m^2 (d) 20 m^2

Second Answer the following questions

(11) In the opposite figure a man moved from point A to point B within 10 s, then from B to C within 6 s, then from C to D within 14 s, what is the velocity by which he moved from point A to point D ?



(12) A car driver saw a child in the middle of the road at a distance of 25 m from his car which was moving with a speed of 12 m/s. He used the brakes after a response time of 0.5 s, so the car is decelerated at 6 m/s^2 till it stopped. Does the car hit the child or not ? Explain your answer.

(13) The light year is the distance covered by light within a year on Earth in a speed of 2.98×10^8 m/s. How many meters in the light year ?
(where the year on Earth = 365.25 days)

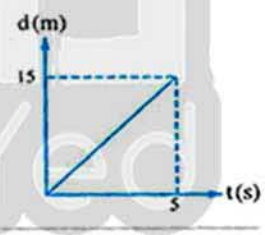
14 An object is projected horizontally from the top of a building and falls down at a distance d from the base of the building within a time t, if $d = (50 \pm 0.2)$ m and $t = (10 \pm 0.5)$ s, **calculate** the initial velocity by which the object is projected.

15 A ball is projected vertically upwards from the surface of Earth and passed a person standing in a window at height of 28 m from the surface of Earth with a speed of 13 m/s, **Calculate :**

(a) The initial velocity of the ball.

(b) The time required by the ball to reach the surface of Earth again.

16 The opposite figure represents the (displacement - time) graph for a runner moving in a straight line with a uniform velocity. **Draw** the (displacement - time) graph for the runner if he moved with a uniform velocity of double his previous velocity in the same direction within the same period of time.



17 An object moves according to the relation : $v_f = 10\ t$, **calculate** each of its initial velocity and acceleration.

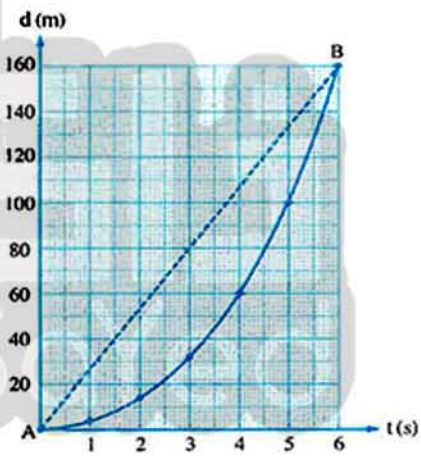
Model Exam 8

First Multiple choice questions

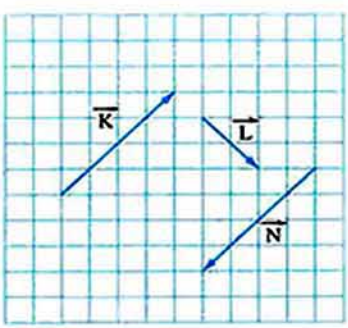
1. The time taken by a car that moves in a straight line with acceleration 2 m/s^2 so that its speed changes by 10 m/s is ..... .
   (a) 0.5 s (b) 2 s (c) 5 s (d) 10 s

2. An object moved in a straight line a distance of 100 m with a velocity of 10 m/s, then it moved on the same line a distance of 200 m with a velocity of 5 m/s, so its average velocity through the whole trip equals ..... .
   (a) 7.5 m/s (b) 6 m/s (c) 8 m/s (d) 30 m/s

3. The opposite figure represents the (displacement - time) graph for an object that moves in a straight line within 6 seconds, so the slope of the dashed straight line AB is ..... .
   (a) greater than the average velocity of the object within 6 seconds.
   (b) less than the average velocity of the object within 6 seconds.
   (c) less than the instantaneous velocity of the object at the sixth second.
   (d) equal to the instantaneous velocity of the object at the sixth second.

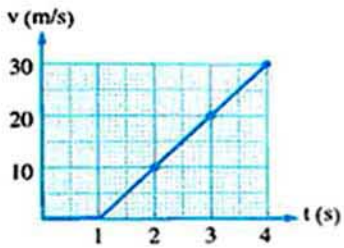


4. The opposite figure illustrates three vectors $\vec{K}$, $\vec{L}$ and $\vec{N}$, which of the following equations is incorrect ? ..... .
   (a) $\vec{K} + \vec{N} = 0$
   (b) $\vec{K} - \vec{N} = 2\vec{K}$
   (c) $\vec{K} = \vec{N}$
   (d) $\vec{K} + \vec{L} + \vec{N} = \vec{L}$



5 The opposite figure illustrates the (velocity - time) graph for an object, so its total displacement ..... .

(a) 120 m
(b) 45 m
(c) 90 m
(d) 60 m

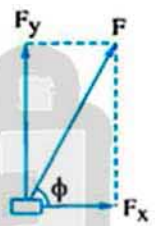


6 A car of mass 1000 kg moves with a uniform velocity of 12 m/s to the east, thus the resultant force acting on the car is ..... .

(a) 12000 N (b) 1200 N (c) 1012 N (d) 0

7 In the opposite figure if $F_y = 2F_x$, then the value of ϕ is ..... .

(a) 60°
(b) 37.67°
(c) 45°
(d) 63.43°



8 A racer claims that he can accelerate his car starting from rest to reach 180 km/h within 4 s, so he is expecting to cover 30 m from rest within a time of ..... .

(a) 12 s (b) 3.14 s (c) 2.19 s (d) 1.25 s

9 Two cars A and B are moving in a straight line where the speed of A increases from 12 m/s to 18 m/s within 3 s while the speed of B increases from 10 m/s to 25 m/s within 10 s. Which of the following statements is correct ? .....

(a) Displacement of A within 3 s < Displacement of B within 10 s
(b) Acceleration of B is double the acceleration of A
(c) Acceleration of A is double the acceleration of B
(d) Average velocity of A within 3 s > Average velocity of B within 10 s

(10) The scalar product of the two vectors $\vec{A}$ and $\vec{B}$ equals 60 units and the magnitude of their vector product equals $20\sqrt{3}$ units, thus the confined angle between the two vectors equals ..... .

(a) 15° (b) 30° (c) 45° (d) 75°

Second Answer the following questions

(11) An object is moving according to the relation $d = 2t^2$, calculate its speed after 5 s.

(12) If the acceleration of an object equals zero, does this mean its speed equals zero ? Give example to your answer.

(13) A tiger jumps horizontally from the top of a rock of a height 6.5 m above the surface of Earth with a speed of 3.5 m/s. Calculate the horizontal range of the tiger's motion. ($g = 10\ m/s^2$)

(14) If $X = (5 \pm 0.1)$ cm and $Y = (7 \pm 0.2)$ cm, calculate $Y - X$.

15 If the maximum horizontal range for a projectile that is projected at an angle above the horizontal equals three times the maximum vertical height that can be reached by it, calculate the value of the projection angle.

16 If the force of viscosity (F) that acts on a ball of radius r which falls in a liquid of viscosity coefficient η is given by the relation $F = 6 \pi \eta r v$ where v is the uniform velocity of the ball, find the measuring unit of the viscosity coefficient η.

17 A box has fallen from a helicopter at a very large height from the Earth's surface during its rise vertically upwards with a uniform velocity of 8.76 m/s, calculate the distance between the box and the helicopter after a period of 3.05 s from the moment of its falling. ($g = 9.8\ m/s^2$)

Model Exam 9

First Multiple choice questions

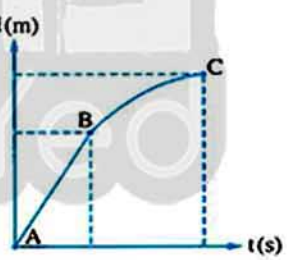
1. A ball of radius 1.7 cm, so its surface area equals ..... .
(knowing that : The surface area of the ball = $4 \pi r^2$)

(a) 2.1×10^{-5} m^2 (b) 9.1×10^{-4} m^2
(c) 3.6×10^{-3} m^2 (d) 0.11 m^2

2. Two balls A and B are projected vertically upwards from the same level such that the initial velocity of the ball A was double that of the ball B, so the maximum height reached by ball A is ..... .

(a) half the maximum height reached by ball B
(b) double the maximum height reached by ball B
(c) four times the maximum height reached by ball B
(d) eight times the maximum height reached by ball B

3. The opposite graph represents the relation between the displacement (d) and the time (t) for an object that moves in a straight line, which of the following statements is correct ? ..... .



(a) The object is at rest during the period BC
(b) The velocity of the object increases uniformly within the period AB
(c) The acceleration of the object within the period AB is positive
(d) The acceleration of the object within the period BC is negative

4. If A = (2 ± 0.01) m and B = (80 ± 2) cm, then the value of (A + B) equals ..... .

(a) (80.2 ± 2.01) m (b) (82 ± 2.01) m
(c) (2.8 ± 2.01) m (d) (2.8 ± 0.03) m

5 Two objects started motion from rest with a uniform acceleration in a straight line for a distance d, if the time of motion of the first body is three times that of the second, then the ratio between the acceleration of the first body to that of the second $(\frac{a_1}{a_2})$ is ..... .

(a) $\frac{1}{1}$ (b) $\frac{1}{3}$ (c) $\frac{1}{9}$ (d) $\frac{1}{81}$

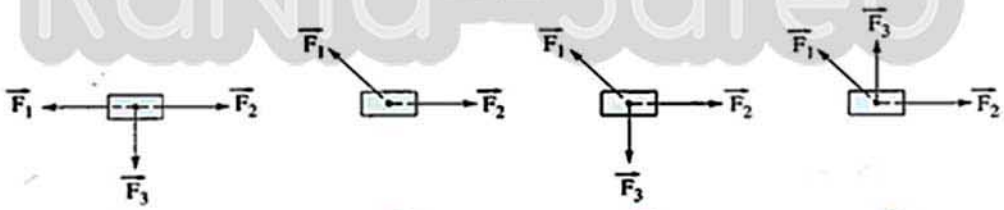
6 A ball is projected upwards with a velocity (v_i) in a direction that makes angle (θ) with the horizontal, when the ball reaches its maximum height, ...

(a) the resultant velocity of the ball equals zero and its acceleration equals zero
(b) the resultant velocity of the ball equals zero and its acceleration doesn't equal zero
(c) the resultant velocity of the ball doesn't equal zero and its acceleration equals zero
(d) the resultant velocity of the ball doesn't equal zero and its acceleration doesn't equal zero

7 If the dimensional formula for the two quantities x and y is $L T^{-1}$ and that for the quantity z is $L T^{-2}$, then the dimensional formula for the quantity k that verifies the equation : $x = y + zk$ is ..... .

(a) LT (b) LT^{-1} (c) L (d) T

8 The object that moves in a uniform velocity is represented by the figure ..... .



(a) (b) (c) (d)

9 Two students are racing in a straight line, if the average velocity of the first student is 4 m/s and that of the second student is 5 m/s and the second student reached the end of the race before the first student by 5 seconds, then the distance of the race is ..... .

(a) 50 m (b) 75 m (c) 100 m (d) 150 m

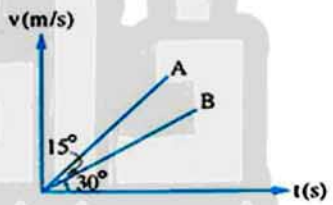
(10) An object started its motion from rest with a uniform acceleration, if its velocity at the end of the fifth second was 5 m/s, then its average velocity when it covers 50 m equals ..... .

(a) 5 m/s (b) 10 m/s (c) 15 m/s (d) 20 m/s

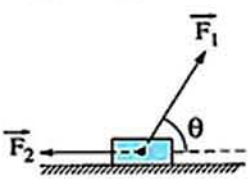
Second Answer the following questions

(11) When the speed and time of motion of a car are measured they are found to be (25 ± 0.5) m/s and (1 ± 0.01) s respectively, **calculate** the distance covered by the car during this period.

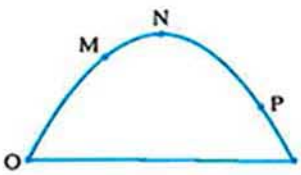
(12) The opposite figure illustrates the relation between the velocity (v) and time (t) for two objects A and B that started their motion from rest, **calculate** the ratio between the acceleration of the two objects A and B respectively.



(13) The opposite figure illustrates a box that moves horizontally with a uniform velocity on a frictionless surface under the effect of two forces, if we decreased the magnitude of the force F_2 while F_1 is kept constant, what will be the change in the angle θ that keeps the box moving in the same velocity ?



14 A player projects a ball upwards from the Earth's surface at an angle to the horizontal and the opposite figure illustrates the path of the ball, arrange the points N, M and P according to the speed of the ball in each point starting from the higher velocity ignoring the resistance of the air.



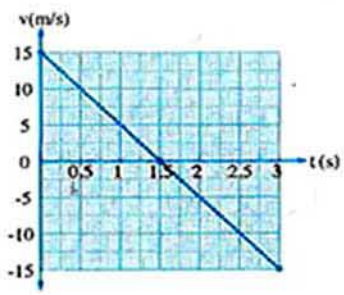
15 In the opposite figure if the resultant vector for the two vectors $\vec{A}$ and $\vec{B}$ is perpendicular to vector $\vec{B}$, calculate the value of vector $\vec{A}$.

16 The speed of a train is decreased in a uniform rate from 96 km/h to 48 km/h through a distance of 800 m due to using the brakes, calculate the distance covered by the train from the moment of using the brakes till it stops if it was moving with the same acceleration.

17 The opposite graph illustrates the relation between the speed of an object that is projected vertically upwards from the surface of Earth and the time, from the figure find :

(a) The speed of the object at the moment it touches the ground.

(b) The displacement of the object.



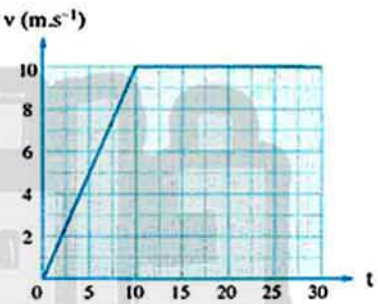
Model Exam 10

First Multiple choice questions

1 Two similar balls fell freely from the top of a sky scraper such that the second ball fell 1 second later after the first ball, if we ignored the resistance of the air and observed the falling of the two balls in the Earth's gravitational field, then the distance between the balls during falling ..... .

(a) remains constant (b) increases
(c) decreases (d) equals zero

2 The opposite graph represents the change in the speed of a girl that runs in a straight race track with the time. If the girl covered a distance of 200 m within 25 s , which of the following choices is correct at the time of 25 s ? ..... .



	The instantaneous velocity	The average velocity
(a)	8 m.s^{-1}	8 m.s^{-1}
(b)	8 m.s^{-1}	10 m.s^{-1}
(c)	10 m.s^{-1}	8 m.s^{-1}
(d)	10 m.s^{-1}	10 m.s^{-1}

3 If an object moved along the circumference of a circle such that its displacement after half cycle becomes 2 π m , then the value of the covered distance is ..... .

(a) π m (b) $\frac{\pi}{2}$ m (c) π^2 m (d) 2 π m

4 The statement that does not express the action and the reaction forces is ..... .

(a) The magnitude of the action force equals the magnitude of the reaction force

(b) The action force is opposite to the reaction force in direction

(c) The action and the reaction forces act on the same object

(d) The action and the reaction forces have the same nature

5 NASA space agency is connecting with the astronauts through radio waves. If the time taken between the transmission from Earth and receiving on the Moon is 1.28 s and the speed of radio waves is 3×10^8 m/s , then the distance between the Earth and the Moon is ..... .

(a) 240×10^3 km (b) 384×10^3 km

(c) 480×10^3 km (d) 768×10^3 km

6 When a body starts its motion from rest in a straight line with an acceleration of 10 m/s^2, this means that ..... .

(a) slope of the (v - t) graph of the body equals 5

(b) slope of the (d - t^2) graph of the body equals 10

(c) slope of the (v - d) graph of the body equals 10

(d) slope of the (v^2 - d) graph of the body equals 20

7 If x = 250 ms , y = 1500 μs , then the value of (x + y) equals ..... .

(a) 0.2515 s (b) 4 s (c) 250.15 s (d) 1750 s

8 A car is moving on a horizontal road with a uniform velocity of 10 m/s and is affected by a frictional forces of 1500 N , so the force by which the engine acts on the car is ..... .

(a) 150 N (b) 1500 N (c) 15000 N (d) 0

9 An object is moving with a uniform acceleration according to the relation : $\frac{2\sqrt{d}}{3}$ So, its speed after 2 s since it started its motion is ..... .

(a) $\frac{4}{9}$ m/s (b) $\frac{2}{3}$ m/s (c) 4 m/s (d) 9 m/s

(10) A car moves in a straight line with a uniform acceleration where its velocity changed from 10 m/s to 90 km/h within 20 s , so the acceleration of the car and its type are ..... .

(a) 0.75 m/s^2 , positive acceleration
(b) 4 m/s^2 , positive acceleration
(c) 0.75 m/s^2 , negative acceleration
(d) 4 m/s^2 , negative acceleration

Second Answer the following questions

(11) **Explain** the decrease in the speed of an object that is projected vertically upwards till it vanishes.

(12) A vector $\vec{v}$ of 16 units makes an angle 50° with the x-axis, **calculate** the vertical and the horizontal components for this vector.

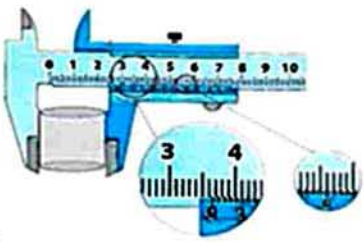
(13) **What happens if** a body is projected at an angle 75° to the horizontal, then it is projected once more with the same initial velocity at an angle 15° to the horizontal (concerning the horizontal range) ?

(14) The opposite figure illustrates the path of a stone that is projected vertically upwards to pass by three similar windows that are at equal distances from each other, **arrange** these windows in a descending order according to the change in the speed of the stone (Δv) during its passing in front of each of them.

15 The opposite figure illustrates a vernier caliper used to measure the radius of a metallic cylinder.
From the figure find :

(a) The measured value for the thickness of the cylinder.

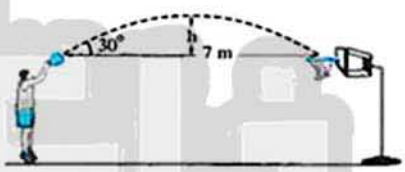
(b) The relative error for that measurement if the actual value of the radius of the cylinder is 3.68 cm.



16 In a basket ball match, a player threw the ball as in the opposite figure, **calculate :**

(a) The speed by which the player should throw the ball to reach the target basket.

(b) The maximum height reached by the ball from the projection plane. ($g = 10\ m/s^2$)



17 A car spent three hours during its trip in a straight line. If its speed during the first hour was 90 km/h and during the last two hours was v and its average velocity during the whole trip was 75 km/h, **calculate** the value of v.